THE
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Chapter No 78

NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

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Fellow Horologists:

In this, the first issue of 1991, we are pleased to be able to continue Charles Aked's series, with #3 of his "Ephemera of Electrical Horology". A leaflet issued by the Synchronome company in January, 1912 is reprinted along with Mr. Aked's penetrating commentary.

An original article by a new member, Mr. George Bacon of Toronto, Canada is most informative on the subject of Earth Cells... read and rejoice!

A comprehensive treatment of the Accutron mechanism is covered in a multi-page reprint supplied by member Melvin Kaye. A fascinating bit of material for the technically oriented member.

The mart pages enjoy a new format, thanks to Co-Editor George Feinstein who has provided a computerized, easy to update version of the older arrangement. Remember... these pages are FOR YOUR USE, without cost, but it is requested that the insertions be brief and limited to a few lines of copy. Additionally, we ask that you advise as soon as the insertion is no longer current so that it may be eliminated providing space for other material.

DUES... Most of the EHS members have paid their 1991 dues, BUT there are always a few folks that need an additional reminder, so for those people, IF you have a notice attached to this journal, you are delinquent and this is your <u>last</u> issue. To everyone else, thanks for your prompt response.

Our elections unanimously re-elected the current slate of officers who offer their thanks for the confidence displayed by the membership.

Enjoy this issue... Good reading ahead.

Martin Swetsky, FNAWCC, President
Harvey Schmidt, } Co-Editors
Dr. George Feinstein } Co-Editors

WHEN Alexander Pope compared men's judgments to their watches, of which "none go just alike, yet each believes his own," he left to posterity the record of a state of confusion regarding the correct time that has happily ceased to exist in most civilized countries. Thanks to the electric telegraph, accurate time is now within the reach of almost everybody.

In the United States the fountain-head of information concerning "the time o' day" is the Naval Observatory, which crowns a hill overlooking the city of Washington. This institution is charged with the duty of testing all the chronometers used in the Navy, and also of operating time-balls, which furnish a visible time signal for the use of mariners at our principal seaports. The necessity for absolutely correct time in connection with these duties led the Observatory to undertake the incidental but really more important task of furnishing a time service to the country at large. Recently, with the aid of radiotelegraphy, this service has been extended far over the adjacent oceans, and mariners out at sea can now regulate their chronometers by the official time signals. The time service on the Pacific Coast is maintained by the observatory at the Mare Island Navy Yard, in California.

Our gravure shows the room at the Naval Observatory from which the time signals are sent out by telegraph twice a day—at noon and at 10 P. M., Eastern Standard Time. (At Mare Island the signals are sent at the same hours of Mountain, or 120th Meridian, Time.) To the right are the two signal clocks, only one of which is used, the other being held in reserve for emergencies. These clocks are mounted on massive piers, in order that they may not be disturbed by the vibrations of the building.

A few minutes before the signal is to be transmitted one of the two chronographs, seen on the stand at the left of the picture, is set in motion. This instrument is connected electrically with the astronomical clock of the Observatory, the error of which is known to a small fraction of a second from observations of stars, and is also connected with the signal clock in such a manner that the seconds of both timepieces are registered by strokes of a pen on a revolving sheet of paper. A comparison of the two records makes it possible to set the signal clock to the correct time, after making allowance for the fact that the astronomical clock keeps "sidereal" or star time, while the signal is intended to show standard solar time.

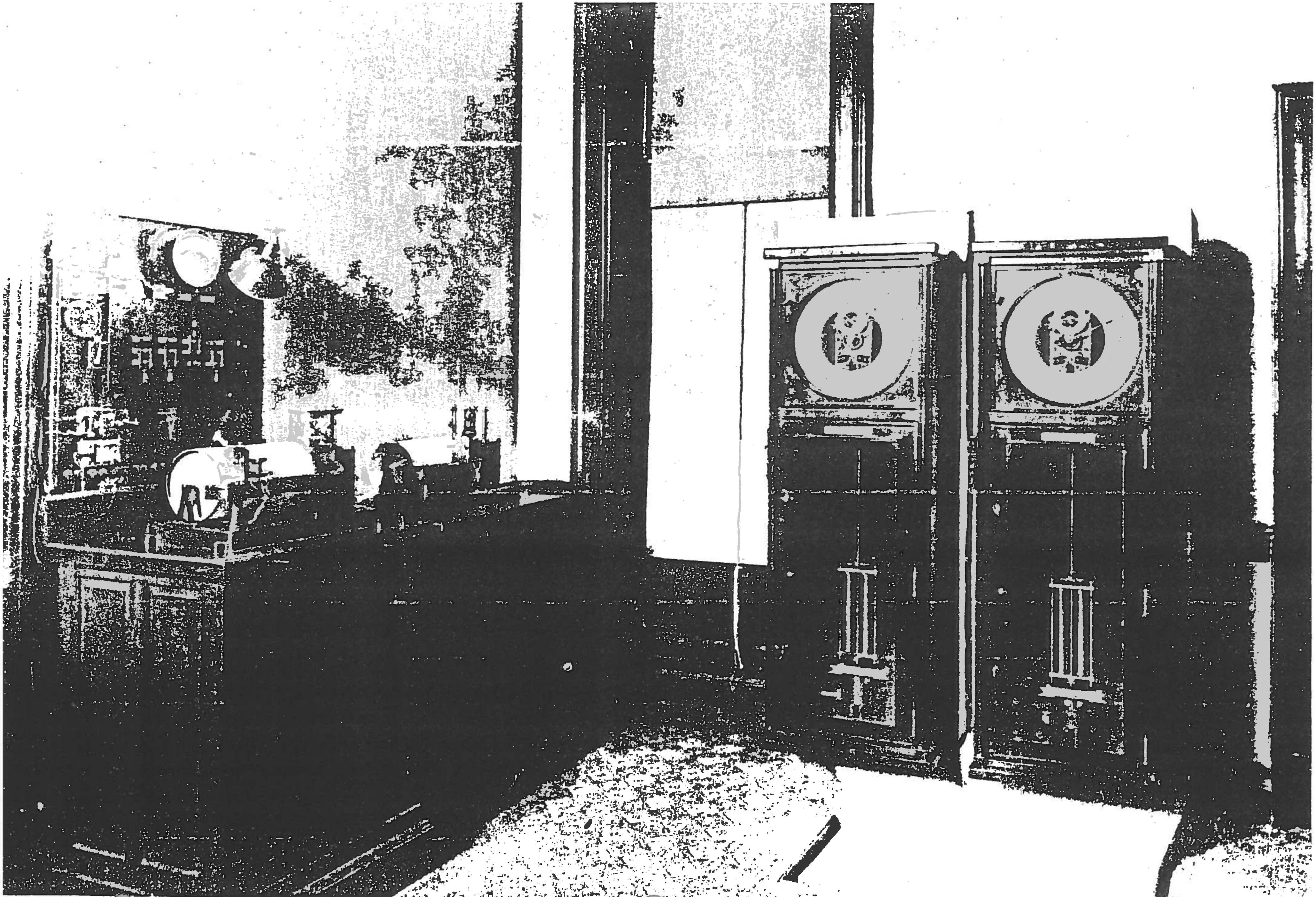
The signal clock having been set, all is in readiness for sending out the signal. This signal is transmitted by the clock itself. At exactly five minutes before the hour a wheel on the axis which carries the second hand begins to operate a telegraph key, at intervals of a second, and at telegraph offices throughout the country the seconds are recorded by the sounders. Practically all other telegraph business is suspended while the signals are being received. In order to facilitate counting, the twenty-ninth, fifty-fifth, fifty-sixth, fifty-seventh, fifty-eighth, and fifty-ninth seconds of each minute are omitted, while during the last minute before noon and 10 P. M. the last ten seconds are omitted, and on the following sixtieth second—the final signal—the key is held down or the contact continued for a whole second. Time-balls in several cities are dropped automatically by this final long contact.

The same impulse from the clock which operates the ordinary telegraph instruments is transmitted over the wire to the great radio station at Arlington, Virginia, where it automatically sends out a "wireless" time signal.

The time signals, if received directly, are seldom in error by as much as two-tenths of a second, while the average error is less than five-hundredths of a second.

PREPARED BY THE EDITORIAL STAFF OF THE MENTOR ASSOCIATION
ILLUSTRATION FOR THE MENTOR, VOL. 4, No. 22, SERIAL No. 122

This 1917 view is certainly a far cry from the modern observatory with the Cesium Atom and Hydrogen Molecule timekeeping standards...



TIME SERVICE ROOM AT UNITED ST[illegible]S NAVAL OBSERVATORY, WASHINGTON

No. 3

THE "SYNCHRONOME" ASTRONOMICAL REGULATOR, a leaflet issued by The SYNCHRONOME Company, 32 & 34 Clerkenwell Road, London, E.C., 16 January 1912.

For all purposes where the finest time-keeping is required.

IMPULSE AND CONTACT EVERY SECOND.

Observatories today mainly rely upon the Graham dead-beat escapement for their Sidereal and Mean Time Clocks. For generations they have been accounted the best time-keeepers available, but contacts for operating subsidiary dials, chronographs, etc., second by second, have been applied to their moving wheels or to their pendulums at the expense of either the time-keeping or the reliability of the contact, and their delicacy has demanded the use of relays which introduce further risks of failure. These difficulties have now been overcome, and the Synchronome Company are in a position to offer an instrument which they can confidently claim to be a better time-keeper than the best Observatory clock, and one which transmits every second a reliable impulse to any number of seconds indicating dials and chronographs.

The clock is of the type introduced by Mr. F. Hope-Jones, M.I.E.E.in 1907, in which his well known "Synchronome" Switch was applied to the free pendulum with detached gravity escapement of Sir H. H. S. Cunynghame, K.C.B., the impulse being given under the pendulum bob.

In this system the whole of the energy impelling the pendulum is transmitted through the surfaces of the contact, thereby ensuring electrical impulses perfectly clean in the make and break and produced without any interference with the pendulum or the escapement. The dials are bound to receive sufficient current to operate them; it is impossible for the switch to work without their doing so.

The improved form now offered is the design of Mr. W. H. Shortt, A.M.Inst.C.E., and the new Inertia Escapement invented by him has secured the novel and important features described overleaf.

Page 2.

ADVANTAGES.

ZERO RELEASE. The pendulum releases the impulse lever while it is passing through the central one-tenth degree of its swing. Variations in the friction of the release do not therefore affect the time of vibration of the pendulum apart from producing an alteration in the arc.

COMPENSATION OF CIRCULAR ERROR. The impulse is delivered during the first one-quarter degree of swing after passing through the centre. This delaying of the impulse introduces an escapement error which decreases with increasing arc, and thus compensates the increase in the circular error produced by increasing arc.

GOVERNED ARC. The inevitable variations of arc due to change of density of the atmosphere and variations of friction are reduced to a minimum, since the impulse lever and pallet are so designed that an increase of arc automatically causes a decrease of impulse and vice-versa.

FREE IMPULSE. During the whole of the time that the lever is giving impulse to the pendulum it is absolutely free since the pallet leaves it before it comes into contact with the remontoire.

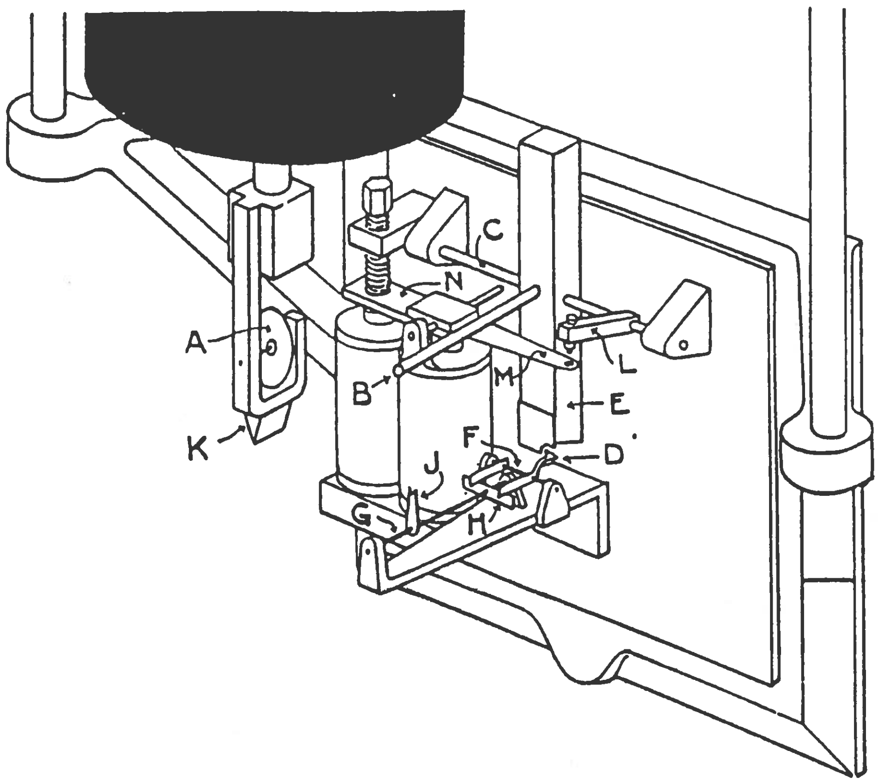
IMPULSE AND CONTACT EVERY SECOND. The escapement mechanism is symmetrical, without duplication; an impulse is therefore given and a contact made each half swing, i.e. once per second as a seconds pendulum is used.

EFFICIENT REMONTOIRE. The contacts are of brief duration and perfectly clean, and owing to the introduction of a spring beneath one of the contact plates the kinetic energy of the impulse lever is stored instead of being wassted. This materially reduces the energy required to reset it.

DECREASED CURRENT. INCREASED THROW. The self-induction and resistance of the circuit are so adjusted that under normal conditions a decrease in the current produces an increase in the throw of the remontoire.

SILENT ACTION. The general design of the mechanism is such that it is very quiet in action, no parts being subject to sharp blows or jars tending to produce wear and tear or noise.

Page 3.



The exact means by which the foregoing advantages are obtained will be readily understood by a reference to the above drawing of the movement. The impulse pallet is in the form of a small wheel "A" mounted centrally on the lower end of the pendulum, and the impulse lever is in the form of a round steel rod "B" pivoted at one end about the horizontal axis "C" and placed so that the free end is immediately over and almost in contact with the top of the pallet wheel "A" when the pendulum is at rest.

The lever is normally held in this position by the catch "D" which engages with the end of the loading bar "E" mounted vertically on the axis of the lever. This catch is pivoted about the axis "F" parallel to the axis of the lever.

The lever is released by means of the trip axle "G" which carries at one end t the small cross bar "H" engaging with the tails of the catch "D" in such a way that a small rotation of the axle in either direction lifts them and depresses the point of the catch. The requisite slight rotation is brought about each time the pendulum passes through its central position, by means of the trip tail "J" which is just hit by the agate knife edge "K" attached to the bottom of the pendulum below the pallet wheel.

The impulse lever being released when the pendulum is in its central position, comes into contact with the pallet wheel then immediately below it, and, as the pendulum continues its swing the lever runs down the edge of the wheel communicating energy to the pendulum.

The downward acceleration of the lever increases with the increasing slope of the place of contact with the pallet until it becomes equal to the acceleration the lever would have were its motion unrestrained by the pallet. Since the acceleration of the lever cannot increase beyond this amount, the lever and pa pallet wheel then part company and the impulse to the pendulum terminates.

The lever "B" is allowed to travel some little distance further before the contact arm "L" comes into contact with the contact spring "M" attached to the armature "N" of the resetting electromagnet. The impulse lever is therefore absolutely free while giving impulse.

If the arc of vibration increases slightly the lever and pallet wheel part company sooner, i.e. before the lever has travelled the normal amount, consequently the impulse is reduced in value; similarly a slight reduction in the arc enables the lever to remain in contact with the pallet for more than the normal distance, with a consequent increase in the value of the impulse. The impulse therefore exerts a governing effect on the arc of vibration.

The inertia of the lever is increased by the loading bar "E" to such an extent that the pallet wheel and lever part company before their plane of contact makes a smaller angle than 45° with the vertical, in order that, should the remontoire fail to act, the pallet wheel on its return swing may be able to push the lever up out of its way.

The movement is mounted on a substantial cast iron bracket, which is tied to the exceptionally solid pendulum suspension bracket by two invar rods placed in the same plane, and having identically the same co-efficients of expansion as the pendulum rod. The movement is fully jewelled.

Any number of subsidiary clocks indicating time second by second may be operated by this master clock and the circuit may also include chronographs or other seconds indicating devices.

Price in mahogany case with bevelled plate glass front, silvered and engraved regulator dial	...	£26 5 0
Subsidiary impulse dials, silvered and engraved, of 10" diameter, indicating time second by second	...	£4 18 6

T H E S Y N C H R O N O M E C O M P A N Y,

32 & 34, Clerkenwell Road, London, E.C.

Telephone :- Holborn 4643.

Notes; in spite of the high flown rhetoric and claims in the leaflet, and the undisputed excellence of workmanship of the actual clocks, it seems that Hope-Jones himself never had any real faith in the design. Only twelve examples were made and in practice found to be no better in performance than that of the ordinary Synchronome clocks, certainly not good enough for an astronomical clock. How the claim could be made that they were suitable for astronomical regulators when there were such superb performers as the Riefler electrically maintained pendulums housed in evacuated cases is not at all clear.

In Electric Clocks published in 1931, Hope-Jones briefly mentions the work of W. H. Shortt started in 1910 and how he took up the work on the Hope-Jones - Cunynghame system and developed his so-called inertia escapement described in the pamphlet. On page 183 of Electric Clocks Hope-Jones gives the briefest of descriptions, the diagram of the pamphlet is reproduced on page 184, but it is clear that his heart is not in it, and in his later editions under the title of Electrical Timekeeping, the subject is almost dropped completely and would have been despatched to oblivion except that W. H. Shortt, in searching for the losses of the inertia escapement proved that it was better to impulse the pendulum above the bob, furthermore the energy lost in unlocking his inertia escapement amounted to about 20%. From this Hope-Jones drew a diagram showing the various losses and from then on would have nothing to do with pendulums impulsed below the bob, a principle expounded by Sir H. Cunynghame who considered the closer the impulse to the centre of gravity of the pendulum, the better. Actually this point should be the point of percussion to avoid any other force being developed by the application of the impulse to the pendulum, in practice it hardly seems to matter; but it is always more difficult to apply the impulse to a swiftly moving point than a relatively slow one. One of the points made in the pamphlet is that the escapement is mounted on a substantial cast iron bracket tied to the exceptionally solid pendulum suspension bracket by two invar rods having identically the same coefficients of expansion as the pendulum rod. Sounds great except this has to be adopted in order to maintain the relative dispositions of the impulse mechanism and the pendulum impulse pallet wheel, a small displacement means that the magnitude of the impulse is changed. The extra complication of the two invar rods would add to the expense.

All W. H. Shortt's developments were translated into hardware by the staff in Hope-Jones' workshop, and in particular by Mr. H. H. Jones (no relative of Hope-Jones but who became a close friend during his long association with the firm). His effort therefore was therefore largely influenced by Hope-Jones who had extremely fixed ideas, in particular being obsessed by his Synchronome Switch. Hope-Jones may also have been influenced by Rudd's free pendulum, this was impulsed below the bob but did not have any unlocking to do and was only impulsed when it required it, all the auxiliary work being carried out by a separate pendulum. Hope-Jones was given Rudd's no. 2 model and later presented it to the Science Museum, as far as the writer is aware the Rudd free pendulum has never functioned for other than a brief period of time, although the first model was apparently quite successful.

Hope-Jones was not complimentary about Matthaus Hipp's astronomical regulator at Neuchatel Observatory, but in 1890-1 the rate of this regulator was - 0.0014 seconds a day for 240 days of observation; of course this regulator was housed in an evacuated cylinder at about 45 mm of mercury pressure. Riefler some time later was producing astronomical regulators with better pendulums and with improvements to the impulsing of the pendulum, these were adopted by all the better observatories throughout the world as their standard timekeeper, hence this standard was the one against which to judge, and no clock with its pendulum working at atmospheric pressure could hope to emulate such a performance, therefore the term astronomical regulator was equivocal in the context of this description. The reader is not allowed to judge for himself because no figures for the performance are quoted, unlike in later years when the daily rate of the Synchronome-Shortt Free Pendulum Clock was dramatised. In other words this clock was one of Hope-Jones' few failures.

Charles K. Aked. 8th August 1984.

EARTH CELLS

Few people are aware that earth cells have been used in any substantial way since Alexander Bain used them to drive his clocks.

In fact "cathodic corrosion control" is used in every town and depends on earth cells. Buried iron pipes and the like will resist corrosion if held at a slight negative charge with respect to the surrounding soil. In practice the negative charge is supplied by a zinc or magnesium electrode connected to the pipe and buried nearby. This power source is used for the same reasons Bain advocated it: it performs dependably virtually forever; it requires no attention; and it is inexpensive. In fact zinc is consumed at a rate of 24 pounds per ampere per year, but with current of only a milliamp or so it will last a long time.

The obvious limitation of earth cells is that multiple cells cannot be connected in series, and the potential of one cell is only about a volt. The actual potential developed depends on the materials of the electrodes, and they can be arranged in a galvanic series:

(Material)	(lbs/amp/yr consumption)	(millivolts negative)
Magnesium	17	1650
Zinc	24	1100
Aluminum	7	1000
Galvanized steel	22	950
Steel	21	700
Ductile iron	20	600
Cast iron	19	550
Lead	70	500
Brass	25	400
Stainless steel	20	300
Copper	45	200
$Cu/CuSO_4$		000

(Electrolyte is moderately corrosive soil.)
($Cu/CuSO_4$ is a reference half-cell of copper surrounded by saturated copper-sulphate solution.)

By subtracting the last-column values, a copper-zinc cell for example gives 0.9 volts, and copper-magnesium gives 1.45 volts.

Bain described his earth cell as two plates, one zinc and one copper or carbon, of 2 square feet each, buried in moist soil at least 3 feet deep and at least 4 feet apart. He noted that a copper wire fastened to carbon will corrode excessively, and suggested an intermediate length of platinum.

This seemed like a lot of digging to me. Also I don't understand the reason for the 4-foot separation. I made a small earth cell by driving stakes into the ground, a 1-inch by 2-foot magnesium rod for anode, and three half-inch copper pipes for cathode, spaced 2 inches around it. I poured some vinegar over it to get electrolysis going. I chose magnesium over zinc for its higher potential. You can buy a megnesium rod from a corrosion protection company.

Even though this earth cell has much less electrode area than Bain's, it has been powering an ATO-type clock for over a month, and shows no signs of weakening. With that load it delivers 100 microamps at 1.2 volts.

George Bacon, Toronto

Accutron—A Chronometric Micro-Powerplant

William O. Bennett
Vice President,
Research & Engineering
Bulova Watch Co., Inc.

SOCIETY OF AUTOMOTIVE ENGINEERS

Reprinted by

BULOVA WATCH COMPANY, INC.

April, 1969

711C

ACCUTRON MASTER TIMER FOR MOON PACKAGE

NEW YORK, April, 1969 -- A programmed long-duration Accutron master timer is part of the Early Apollo Scientific Experiments Payload (EASEP) to be landed on the Moon by the first United States astronauts to reach the lunar surface.

EASEP, which includes two scientific experiments systems, the Passive Seismometer and the Laser Ranging Retro-Reflector, is scheduled to be carried to the moon by the Apollo 11 mission, tentatively planned for July launch from Cape Kennedy.

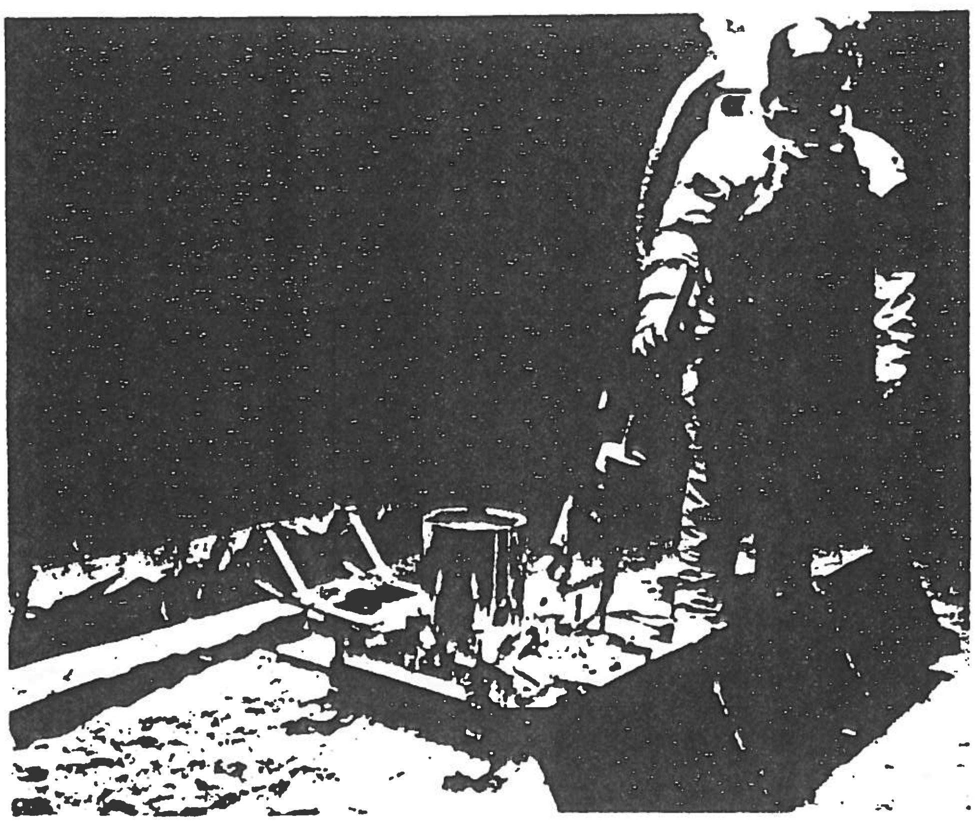
The master timer, which employs a 360-cycle tuning fork as its time base, is incorporated in the 100-pound Passive Seismometer "package", a self-contained seismic station equipped with panels of solar cells and its own radio transmitter. On the moon, the Passive Seismometer will detect and report the slightest movements of the lunar crust as well as "moon-quakes" caused by motions of the moon's interior.

The Accutron timer, which is independently powered by tiny mercury oxide cells, will be programmed to trigger shut-offs and other pre-scheduled events over a 12-month period, according to Egbert Van Haaften, director of Bulova Watch Company's Timer Laboratory.

He said that EASEP is less complex than the Apollo Lunar Surface Experiments Package (ALSEP), a full geophysical station to be placed on the moon by the second and third manned moon-landing missions of the National Aeronautics and Space Administration's Project Apollo.

Both ALSEP and EASEP were developed, designed and built by the Bendix Aerospace Systems Division and both incorporate Accutron long-duration master timers, he pointed out.

"Different configurations of Accutron tuning-fork timers, clocks and switches have been ordered for and successfully used by NASA's space program, starting in 1958," Van Haaften said. "Consequently, we are especially proud that our Accutron timers will be among the first American equipment to be landed on the moon by Apollo astronauts."



ON THE MOON - The deployment of the astronauts' training model of EASEP's Passive Seismometer shows how an astronaut on the Moon will emplace the self-contained seismic station equipped with an Accutron master timer. EASEP is powered by panels of collapsible solar cells. It is designed to report the Moon's seismic conditions via radio broadcasts for 12 months after the astronauts have returned to Earth. Consequently the long-duration master timer will be programmed to trigger shut-offs and other events throughout that period.

Accutron® — A Chronometric Micro-Powerplant

"The content of this article is from a speech given by the writer at the International Summer Meeting in Montreal, Canada, June 1963, of the Society of Automotive Engineers".

William O. Bennett
Bulova Watch Co., Inc.

ACCUTRON* WRIST TIMEPIECE MECHANISM

Tuning Fork - The greatest difference between Accutron timepieces and conventional watches lies in the use of a tuning fork in place of a balance wheel and hairspring as the time standard. The Accutron tuning fork is shown in Fig. 1. This part is more complex than tuning forks employed for other purposes, as can be seen from the photograph. Its application to a wrist timepiece is responsible for its relatively complex construction since it must have unusual characteristics to permit exposure to a wide variety of environmental conditions. Furthermore, it must be relatively small for installation in a mechanism which must fit within a conventional man's wrist watch case.

This tuning fork would be classified as the weighted type, because of the mass attached to the end of each tine. These two masses constitute the permanent magnet portions of the electrodynamic transducer system employed to drive the tuning fork and control its amplitude. These masses are so mounted that their centers of gravity are directly above the constricted sections of the tines adjacent to the base of the fork. This results in the horizontal velocity vectors of the two masses being substantially in the same line, thereby reducing the amplitude of the vertical component of vibration of the tuning fork on its mounting plate to a minimum.

Tuning forks normally have straight tines. As shown on Fig. 1, this fork has a "knock-kneed" appearance, resulting from the inward bow of each tine. One tine is bowed to economize on space by permitting the cylindrical power cell or battery to intrude upon the space nominally occupied by the tuning fork, without touching the adjacent tine. The other tine is curved for symmetry. Unlike most tuning forks, which usually employ a mounting extending beyond the base of the fork, the mounting stem by which the Accutron tuning fork is attached to the pillar plate extends inwardly between the tines. This inward stem not only economizes on space for the fork but brings the mounting member as close as possible to the vibrating masses, thereby providing optimum decoupling between tuning fork and pillar plate for a given mounting elasticity. In addition, there is a clearly visible constriction in the mounting stem at the point where it joins the fork base. This constriction is of sufficient stiffness to maintain the fork in proper alignment, yet decouples the tuning fork base sufficiently from the mounting plate as to eliminate any effects of unavoidable small differences in frequency between the tuning fork tines. Without the elastic decoupling provided by this mounting system, the timepiece

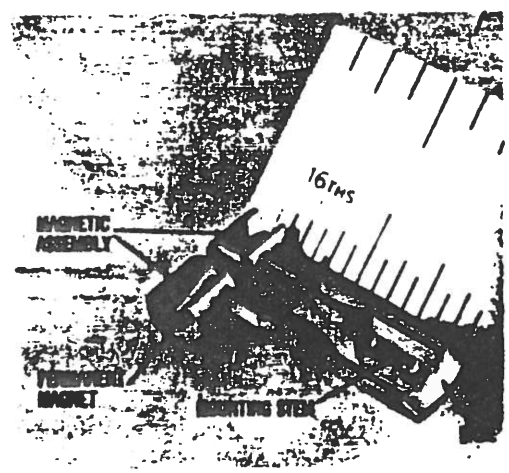


Fig. 1 - Accutron tuning fork

*Registered trademark, Bulova Watch Co., Inc.

ABSTRACT

This paper describes the Accutron mechanism, its construction and functioning. It is characterized by a tuning fork, electromagnetically driven with energy from an electrochemical cell, or battery, by means of a transistorized electronic circuit. Vibratory motion of the tuning fork is converted into rotary motion, to drive a series of gears. It can be used as a chronometric motor for applications where low speed, tiny size, and power output of the order of microwatts can be obtained. One example is the use of the basic Accutron movement, supplemented by suitable gearing, to perform switching functions in certain satellites months or years after launching, at a time which is preset on suitably calibrated dials.

rate would be affected by being placed on surfaces reflecting different amounts of restraint to the assembly.

The mechanical design of these tuning forks requires careful calculation to avoid overstressing of the material, with resulting fatigue effects and drifting of tuning fork frequency with time. Careful design and control of manufacturing processes have resulted in tuning forks which have a drift in frequency less than 10 ppm/year -- well under 1 sec per day. Changes of fork frequency due to variations in temperature is avoided by the use of NiSpan-C, a precipitation hardened nickel alloy having a thermoelastic coefficient which can be made substantially zero over a fairly wide range of temperatures, by proper processing and heat treatment. This material is further characterized by low elastic hysteresis, resulting in a tuning fork requiring minimum power for its operation.

The Accutron mechanism was designed for use as a wrist timepiece. While the frequency of the Accutron tuning fork is far less affected by the wearers' habits and by the condition of lubrication in the movement than the frequency of the best balance wheels and hairsprings,provision must nevertheless be made for field correction of tuning fork rate. Such corrections rarely exceed several seconds per day and a very simple calibrated regulating system on the tuning fork itself provides the necessary small range of adjustment. The regulating system is shown on Fig. 2.

Each tuning fork tine is provided with a regulator, held friction tight by a riveted attachment on the magnetic element. The visible serrations on each regulator serve as calibrations for observing the amount of rotation of these regulators and also provide convenient means for rotating each, against the friction which prevents accidental rotation. Rotation of these regulators moves a small portion of the mass of the tuning fork, in relation to the tuning fork base, thus making the effective length of the tuning fork adjustable to a very small degree.

The serrations on each regulator form seven divisions (four projections and three indentations). Moving either regulator the width of one of these divisions alters the tuning fork frequency 23 ppm, resulting in a rate change of 2 sec /day. Rotation away from the tuning fork base causes an effective lengthening of the tine and results in a decrease in tuning fork frequency. For rate changes of a few seconds per day it is satisfactory to move only one regulator. For larger corrections in rate, both elements should be adjusted to avoid unbalancing the tuning fork tines.

Fig. 3 shows the arrangement of the tuning fork with associated electronic circuit as mounted on the pillar plate of the timepiece movement. The view shown is from the dial side. The tuning fork is caused to vibrate continuously by means of the electronic circuit which meters driving current pulses to the transducer system, energy being supplied by a self-contained power cell or battery, not visible in this picture. The tuning fork vibrates at its natural frequency of 360 cps, at a fixed amplitude established by the system parameters. All circuit elements and connections are mechanically attached to two complex plastic molded parts. These two coil form assemblies are joined by three wires, passing under the base of the tuning fork, and constitute a complete module which can be replaced in the field if circuit trouble is experienced, since field repair of the circuit elements is not practical.

Vibratory-To-Rotary Motion Conversion - The vibratory motion of the tuning fork is converted into rotary motion for turning the hands, by a ratchet and pawl system of simple construction. Fig. 4 shows the arrangement of the essential parts of the indexing mechanism, from the train (or rear) side of the movement. One tine of the tuning fork has attached to it a straight spring tipped with a tiny jewel which engages ratchet teeth on an "index wheel," advancing this wheel one tooth for each complete oscillation of the tuning fork. A pawl holds the index wheel in position during the return stroke of the index jewel. The pawl finger and jewel are similar to the index finger and jewel, except that the pawl finger is attached to the pillar plate of the movement. The shaft of the index wheel is provided with a pinion for turning the timepiece hands through a suitable train of gears.

The use of a ratchet and pawl mechanism to obtain rotary motion from oscillatory motion is, of course, not new. Nevertheless, the design and construction of a ratchet and pawl system to meet the requirements of the Accutron device

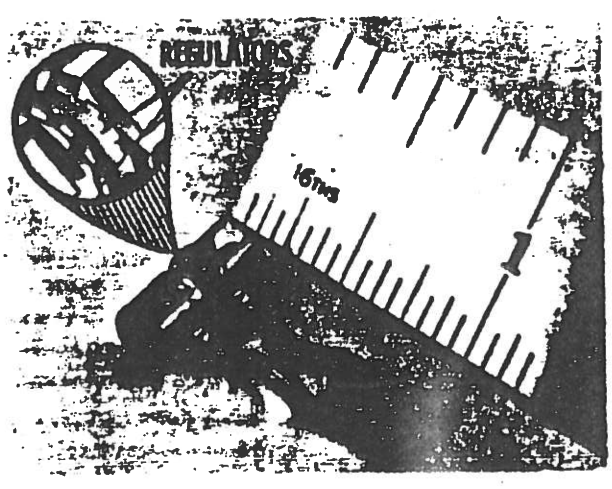


Fig. 2 - Tuning fork showing regulator enlarged

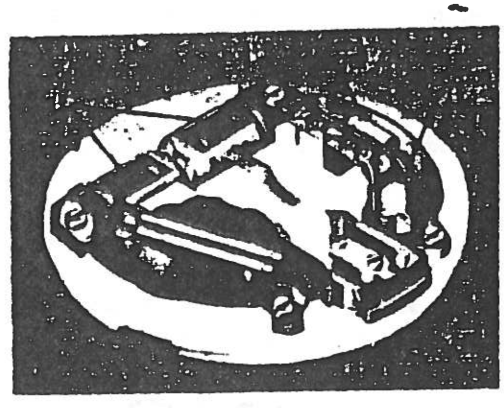


Fig. 3 - Tuning fork and associated circuit elements

presented several interesting and challenging technical problems:

1. Absolute synchronism between tuning fork vibrations and index wheel revolutions must be maintained, unlike many ratchet and pawl applications where varying numbers of teeth may be "gathered" during each cycle of the oscillating mechanism and accurate indexing is not required.

2. Design and construction of the indexing mechanism must provide for reasonable variations in both the stroke and the end points of travel of the indexing jewel, yet advance the index wheel one tooth per stroke, unlike most applications where one or both end points of travel of the indexing ratchet are rigidly fixed by mechanical stops.

3. This indexing mechanism must function reliably and without significant wear at high frequency, specifically 360 times per second (over 11 billion times in a year), as compared with the usual slow moving applications of the ratchet and pawl mechanism.

Unlike conventional watches, the Accutron timepiece owes its accuracy and reliability to basic engineering and design, rather than to the skill of the artisans responsible for producing and assembling the mechanism. Nevertheless, the ingenuity of the design of the Accutron indexing mechanism is frequently lost sight of, in view of the incredibly small parts required in solving the three basic problems outlined above. The index wheel, for example, is only 0.095 in. in diameter and 0.0015 in. thick. It is made of beryllium copper alloy, fully precipitation hardened. This wheel has 300 perfect ratchet teeth, the straight sides of which measure only 0.0004 in. high x 0.0008 in. long. The rectangular index and pawl jewels are of synthetic ruby 0.007 x 0.007 x 0.002 in., polished on all six sides and attached to their supporting spring fingers by heat cured epoxy cement. The spring fingers are about 1/8 in. long, of spring material 0.0006 in. thick x 0.005 in. wide. Although these various tiny elements are easily damaged in handling, assembly, and repair, the indexing mechanism when protected by the timepiece case is rugged because of, not in spite of, the tiny dimensions of the parts involved.

Fig. 5 shows the relationship between the index wheel and the two jewels in contact with it. Also indicated are the forces which result from the preloading of the spring fingers to which the jewels are attached. The spring forces of the index and pawl jewels not only hold them in firm contact with the index wheel teeth, these forces also exert a torque on the wheel in a direction opposite to its forward motion. This tendency to "draw" the index wheel back against one of the jewels is very important to the reliable operation of the Accutron indexing mechanism. In actual practice, each cycle of vibration of the tuning fork causes the index wheel to advance 1-1/2 teeth beyond the initial position, then "draw" back 1/2 tooth for a net advance of exactly one tooth per cycle. Furthermore, the mechanism will tolerate a variation in tuning fork amplitude of about ± 50% before improper indexing occurs. The following discussion will show how this is accomplished.

Fig. 6 is a diagrammatic representation of the dynamic sequence of events in the indexing mechanism, for three widely different amplitudes of vibration of the tuning fork. The mechanism is so constructed and adjusted that, when the tuning fork is at rest, with an index wheel tooth engaged by the pawl jewel (and held there by the "draw" effect described above), the index jewel is located several teeth away in a position halfway between two teeth. The amplitude of travel of the index jewel is conveniently expressed in terms of tooth length. Fig. 6A shows the idle position, as described.

Figs. 6B and 6C show a complete cycle of oscillation at an amplitude of one tooth (1/2 tooth right to 1/2 tooth left of the rest position). In moving to the right 1/2 tooth, the index jewel picks up tooth No. 7, and on its return stroke to the left it drives the wheel far enough for the pawl jewel to drop off the end of tooth No. 2, so that the wheel is advanced one tooth. Further oscillations at the one-tooth level of amplitude would advance the wheel exactly one tooth per cycle.

Figs. 6D-6F indicate the sequence of events at an amplitude of two teeth (one tooth to the left and one tooth to the right of the rest position). The index jewel, in going one tooth to the right, drops off tooth No. 7, and goes half-way along tooth No. 8. On the return stroke, however, the first half tooth of travel accomplishes no movement of the

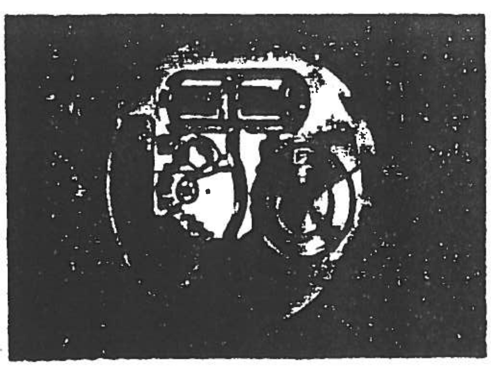


Fig. 4 - Accutron indexing mechanism - (rear view)

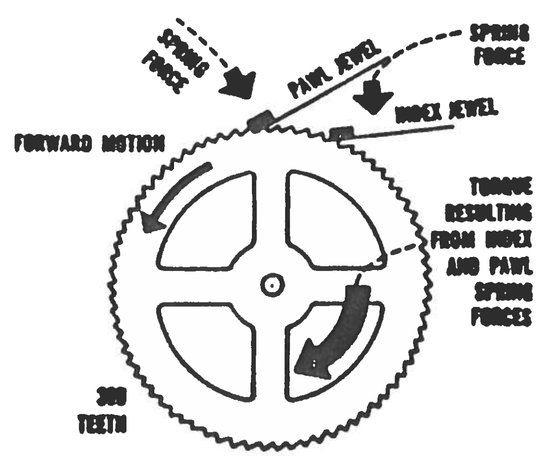


Fig. 5 - Diagram of indexing mechanism

index wheel, since the index jewel does not begin to drive the wheel until it strikes tooth No. 7. In Fig. 6E, tooth No. 2 has passed beyond the pawl jewel; but after the start of the return stroke the "draw" effect exerts torque on the wheel to bring it back 1/2 tooth to the position shown in Fig. 6F. Thus, with a two-tooth amplitude of travel of the index jewel, one tooth rotation of the index wheel results per cycle of oscillation of the tuning fork.

Figs. 6G and 6H show the effect of the three-tooth amplitude. The index jewel, in going to the right 1-1/2 teeth, picks up tooth No. 8. At the other end of the stroke, it has moved tooth No. 8 into the position where tooth No. 5 was. The pawl jewel has dropped off the end of tooth No. 4, resulting in a three-tooth advance of the index wheel.

It can be seen that for any amplitude from just over one tooth to just under three teeth amplitude, the index wheel advances one tooth for each vibration of the tuning fork. When the total travel of the index jewel reaches three teeth on the index wheel, this wheel advances more than one tooth for each tuning fork vibration; in fact, it advances three teeth, and under conditions where the tuning fork reached such an amplitude the hands would advance at three times their proper rate.

The amplitude of vibration of the tuning fork is nominally such that the index jewel travel is about two teeth. From the above discussion it has therefore been shown that the indexing mechanism will tolerate about ± 50% variations in tuning fork amplitude from this nominal value before the timepiece hands fail to advance in exact synchronism with the vibrations of the tuning fork.

One of the less obvious but nevertheless very important adjustments in the assembly of the ratchet and pawl mechanism to permit it to function as described, is that which assures that the relative position of the two jewels is exactly as shown on Fig. 6A. Maintaining an exact number of index wheel teeth between the two jewels is not necessary. However, the index jewel must rest in the middle of a tooth in the idle condition. An obvious expansion of the diagrams shown in Fig. 6, but with the index jewel resting at points other than in the center of a tooth as in Fig. 6A, will readily show a rapid narrowing of the optimum ± 50% amplitude tolerance as the phase relationship of the two jewels deviates from the proper value. The minute teeth and the small dimensional adjustments required, make a normal approach to establishment of the critical relationship between the two jewels in question a near impossibility. Instead, a reduced voltage is applied to the electronic circuit, during adjustment, to cause the index jewel to oscillate at very slightly over one tooth amplitude. The pawl finger is attached to a movable support which has a cam adjustment permitting the pawl jewel position to be advanced or retarded. With slightly over one tooth amplitude of the index jewel as described, the pawl jewel position is varied until the index wheel revolves steadily -- proof that the two jewels are now in the proper phase relationship. Clamping screws on the pawl finger support are tightened to assure that this element cannot move in service.

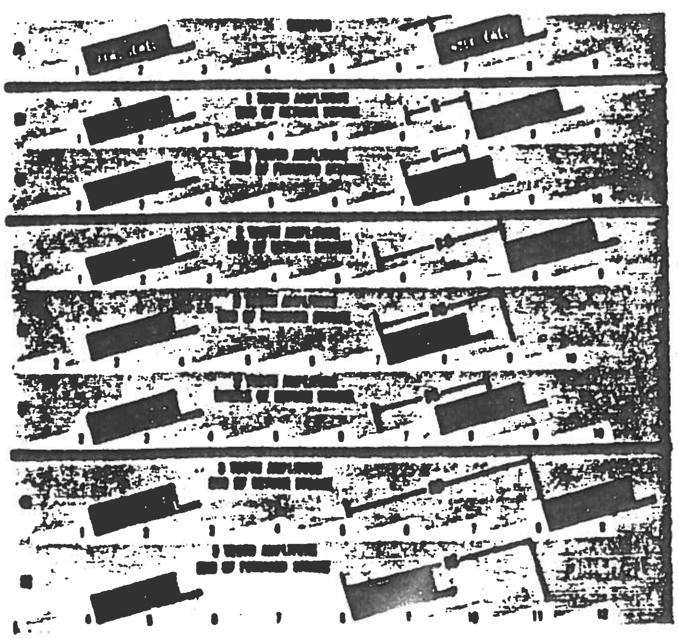


Fig. 6 - Diagram of indexing mechanism operation

Electro-Dynamic Transducer System - Reliable operation of the Accutron indexing mechanism, as described above, is dependent upon the tuning fork amplitude being controlled so as to remain at or near a predetermined value under all conditions of use as a wrist timepiece. The transducer system driving the tuning fork is the key to the amplitude control system, since it not only drives the tuning fork electromagnetically, under the action of current pulses delivered by an electronic circuit, but also permits the circuit to sense the amplitude of the tuning fork.

The elements of the transducer system are shown on Fig. 7, with one assembly partially sectioned to show the details of its construction. The moving part of each transducer includes a cup-like part of magnetic material (actually of low carbon steel) together with a conical permanent magnet mounted inside the magnetic cup. Associated with each cup and magnet assembly is a coil of wire, fixed to the plate on which the tuning fork is mounted, and positioned in the annular space between the inside of the cup and its permanent magnet. Each of these coils is wound with 8000 turns of No. 55 insulated wire. These transducers are similar in construction to permanent magnet loudspeakers, except that in the Accutron construction the magnet moves instead of the coil as in a speaker. One transducer contains a single coil of wire, identified as a drive coil; the other transducer contains a drive coil and an additional coil identified as a phase sensing coil.

The drive coils receive the current pulses required to maintain the tuning fork oscillations. In addition, vibration of the magnet and cup assemblies attached to the tuning fork tines induces an alternating voltage in the respective coils. This voltage is directly proportional to the amplitude of vibration of the tuning fork, thus permitting the electronic circuit to sense this amplitude. The function of the phase sensing coil is to control the instant in each cycle during which the driving current pulse is delivered to the drive coils. The electromechanical transducers, therefore, serve a triple purpose:

1. They convert pulses of electrical current into mechanical impulses which drive the tuning fork.

2. They provide the means by which the electronic circuit may sense the tuning fork amplitude.

3. They control the instant in the tuning fork cycle during which the driving current pulse is delivered.

The tuning fork frequency is, of course, fixed within very narrow limits; the mechanical dimensions of the transducer elements can be readily controlled as can the flux in the air gaps and the number of turns of wire on each of the three coils. The conversion factor between the a-c voltage induced in the transducer system and the mechanical amplitude of the tuning fork is therefore predetermined by the design of the transducer elements and can be maintained within narrow limits in mass production. The following paragraphs describe the manner in which this transducer system, coupled with an electronic circuit, controls the mechanical amplitude of the tuning fork at the optimum value for reliable operation of the mechanical indexing system which turns the timepiece hands to indicate time.

Operation of Electronic Circuit - Fig. 8 shows the electronic circuit employed to drive the tuning fork, in combination with the electrodynamic transducer system. The transistor shown is germanium, type PNP. It is used in this application as a switch, rather than as an amplifier. It is caused to conduct current from emitter to collector, once each cycle, thus delivering pulses of current through the two tuning fork drive coils connected in series, as shown on the schematic circuit diagram. The transistor, in this common emitter circuit, can pass collector current only when current is flowing in the base circuit. Key elements in the base circuit operation are the 0.3 mfd capacitor with the 3.9 megohm resistor across it. It is this R-C combination which permits the circuit to drive the tuning fork in a normal manner over a wide range of temperatures, although the transistor characteristics are known to vary widely with temperature.

Operation of the base circuit to trigger the transistor once each cycle is most readily explained by assuming the tuning fork to be vibrating at substantially its normal amplitude. The diode characteristic of the emitter-to-base of the transistor permits the alternating voltage induced in the phase sensing coil to charge the capacitor to a voltage higher than the cell voltage. The base of the transistor is therefore biased positively relative to the emitter by means of the R-C combination mentioned above, during most of each tuning fork cycle, thus maintaining the collector circuit in a quiescent condition. The resistor is provided to cause a portion of the charge on the capacitor to leak off, values of R and C being so chosen that the time constant of the combination is long compared to one tuning fork cycle. During a relatively short interval in each cycle as the voltage induced in the phase-sensing coil approaches its peak (negative) value, the base becomes negative with respect to the emitter and a pulse of current flows from the emitter to the base of the transistor to replace the charge on the capacitor. It is this base current pulse which makes the collector circuit conducting for a brief period, once each cycle.

The 0.01 mfd capacitor in the base circuit, not previously mentioned, prevents self-oscillation of the circuit. Since the phase-sensing coil and one of the drive coils are wound on a common coil form, they are closely coupled magnetically. High frequency feedback oscillations resulting from this close coupling are effectively prevented by the 0.01 mfd capacitor connected as shown on Fig. 8.

The effect of driving impulses upon the frequency of any mechanical vibrating system is zero for instantaneous impulses applied at the point of maximum velocity. This point falls midway in the oscillatory swing. Impulses of finite duration will have a negligible effect upon the frequency of the tuning fork if the impulses are symmetrical about the point of maximum velocity of the tines. Since the voltage induced in the phase-sensing coil of the transducer is proportional to the instantaneous velocity of the tuning fork tines, the base potential reaches its maximum negative value at the exact midpoint of the oscillations of the tines (middle of swing). Driving pulses therefore occur at this time, thereby

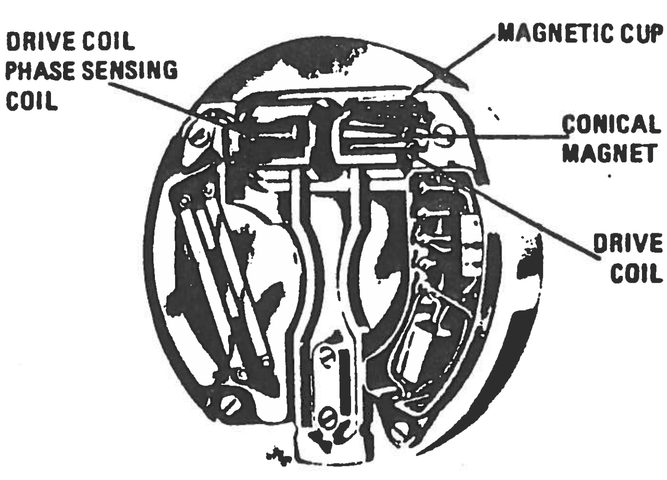


Fig. 7 - Cutaway view of electrodynamic transducer system

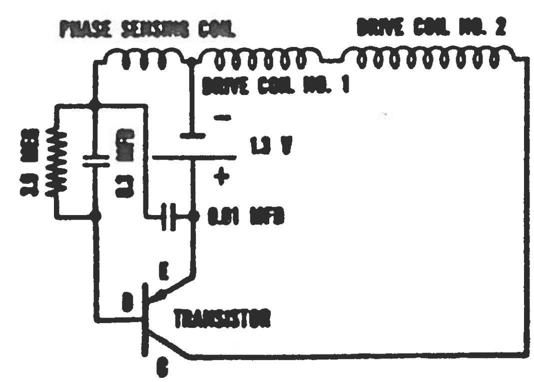


Fig. 8 - Schematic diagram of Accutron circuit

minimizing any disturbance to the natural frequency of the tuning fork.

The operation of the Accutron amplitude control system is similar in principle to the functioning of a permanent magnet d-c motor. In the latter, the back emf at no load is opposite in potential and almost equal in voltage to the operating voltage applied across the brushes, resulting in operation at very low current and practically fixed speed for a given operating voltage. Furthermore, the speed is nearly independent of load, for light loading, since a small reduction in speed results in a large increase in driving current in proportion to the relative change in speed.

The amplitude of the alternating voltage induced in the Accutron drive coil circuit, equivalent to the back emf of the motor discussed above, is typically about 90% of the cell voltage. This is $0.9 \times 1.3 = 1.17$ v. The collector circuit of the transistor is rendered conductive by the base circuit when the voltage in the drive coils is approximately at its maximum instantaneous value and opposite in polarity to the cell voltage. Under these conditions, the net voltage is 0.13 v. The two drive coils have a total resistance of approximately 13,000 ohms. If the transistor were a perfect switch, the pulse current under these conditions would be

$0.13/13 \times 10^3 = 10^{-5}$ amp or 10 microamp.

It seems obvious that a mechanical disturbance which caused the tuning fork amplitude to drop 10% below its nominal value would reduce the amplitude of the alternating voltage induced in the drive coils by this same percentage, resulting in approximately doubling the current in the driving pulses and a rapid return of the tuning fork amplitude to its nominal value, because of the large increase in driving energy per cycle at the reduced amplitude. Similarly, a 10% increase in tuning fork amplitude, resulting from a mechanical disturbance, would reduce the driving current pulses to zero and the mechanical amplitude would drop rapidly to its nominal value.

In practice the amplitude control system functions approximately as outlined in the above simplified explanation. The driving current pulse is not, of course, instantaneous nor is it completely independent of the characteristics of the individual transistor used. Nevertheless, the system functions about as described. The transistor collector circuit is quiescent for about 70% of each tuning fork cycle. During the 30% of a cycle the current is flowing, the net voltage is changing slightly, due to its sinusoidal characteristic. Furthermore, by using transistors which have a base-current-to-collector-current gain above a certain minimum value, operation of the circuit is substantially independent of transistor characteristics, over a wide range of temperature.

The voltage of the cell which powers the Accutron circuit is, in fact, the primary control for the tuning fork amplitude. In principle, the system described above converts the mechanical amplitude of the tuning fork into an alternating voltage, compares this induced voltage to the cell voltage and maintains the difference at approximately a fixed value, predetermined by the system parameters. The cell used was chosen for its voltage characteristic. It is basically a mercury cell, of slightly special construction for this application. This cell has a nearly constant potential of 1.3 v for approximately 99% of its useful life, after which its potential drops rapidly to zero and the timepiece stops. This cell provides well over one year of operation under the normal conditions of environment to which a wrist timepiece is exposed. The electrodynamic transducers, the transistorized circuit and the special mercury cell therefore combine to maintain the Accutron tuning fork at the mechanical amplitude required for reliable functioning of the indexing system, and to return it rapidly to the prescribed amplitude in the event that the amplitude is changed by a mechanical disturbance.

CHARACTERISTICS OF ACCUTRON MECHANISM

Performance characteristics of this mechanism and the effects of various environmental conditions on its performance are discussed in the following paragraphs. It might be mentioned that this device, in its commercial version, is marketed as a man's wrist timepiece with a guarantee that it will not gain or lose more than a minute per month in normal use. This is not intended to indicate that the instantaneous rate will not exceed 2 sec per day, gaining or losing, under any combination of environmental conditions. The cumulative effects of occasional brief exposure to a variety of abnormal environmental conditions will rarely change the nominal rate as much as a minute a month and the guarantee of specific accuracy is therefore entirely practical for normal use as a wrist timepiece. The following effects must nevertheless be considered when using this mechanism as a chronometric motor for technical applications, where constant exposure to abnormal environmental conditions may be a requirement.

Acceleration - The rate of the tuning fork changes 4.5 sec/day per g, parallel to the axis of the fork. The rate is faster when the force due to the acceleration is directed from the base toward the free ends of the tines; slower when the force is reversed in direction. The tuning fork rate is practically unaffected by acceleration at right angles to the tuning fork axis. However, accelerations of approximately 20 g's perpendicular to the plane of the tines or 10 g's in the plane of the tines, perpendicular to the fork axis, will cause the fork to stop due to mechanical interference with the mounting plate.

Accuracy - The basic accuracy of the tuning fork in a fixed attitude and under fixed conditions of temperature and pressure is not influenced by pivot friction, lubrication, or the like, and its rate under these conditions is constant, for most practical purposes. Change in rate with time (drift) has been measured repeatedly for typical tuning forks of this construction, vibrated constantly by the associated circuitry and cell, the rate of change in each case being less than 1 sec/day/year. For its normal use as a wrist timepiece, the total effect of the mechanical loading of the fork by the indexing mechanism required to turn the hands, is approximately 1.5 sec/day. Variations in this figure due to changes in lubrication, or the like in the mechanical system are therefore very small. Regulation of timekeeping, under fixed conditions of environment and attitude, is readily accomplished to less than 1 sec/day.

Altitude - The effect of altitude and pressure on the rate of this device is shown on Fig. 9. As shown, the device gains at increasing altitudes, the effect being directly proportional to the reduction in pressure. The rate of change is 0.71 sec /day/in. Hg change in pressure. This effect is caused by the change in density of the moving air column which, in principle, forms part of the mass of the vibrating tuning fork.

Except for the change in rate, the device in comparatively unaffected by a reduction of pressure. Extended operation under high vacuum conditions has presented no problem, although there is a small reduction in operating current resulting from the elimination of air damping.

Attitude - The frequency of the tuning fork is unaffected by changes in attitude, if the tuning fork axis remains horizontal. With the tuning fork axis vertical, the rate will change 4.5 sec/day in comparison with the rate with the fork axis horizontal. The rate in the "tines down" position is faster than when the fork is horizontal; the rate "tines up" slower than the rate in the horizontal position.

The reason for the attitude effect is that in the tines down position, for example, the effect of gravity on the weighted tines is added to the elastic return force of the tuning fork, to make the frequency higher than if the gravity effect were absent as, for example, in the horizontal position of the fork. These timepieces are normally regulated to lose 1.5 sec/day in the horizontal position to compensate for the frequent occurrence of the "tines down" position (12 down) when worn in the usual manner on the outside of the wrist. If worn on the inside of the wrist, the timepiece must be regulated to gain 1.5 sec/day in the horizontal position for optimum performance.

Magnetism - Figs. 10 and 11 show the effects of exposure to d-c magnetic fields of various strengths, for two different directions in relation to the orientation of the tuning fork. The tuning fork, in addition to being fitted with permanent magnet elements, is ferro magnetic and its frequency is, of course, affected by the presence of magnetic fields. The residual effect upon rate, for the field strengths shown, is nevertheless small.

Fig. 12 shows the demagnetizing effect of exposing the permanent magnet system to a-c magnetic fields of various strengths. Exposure to a field of 200 gauss demagnetizes the magnets about 10%. This would have little practical effect upon the operation of the timepiece, other than to increase the mechanical amplitude of the tuning fork 10%, thereby causing a slight increase in driving current. Exposure to a-c or d-c fields above about 200 gauss should be avoided because of the demagnetizing effect shown.

The stray magnetic field, adjacent to any point on the wrist watch case in which this device is normally housed, is a maximum of 28 gauss. This is a d-c field, modulated by a very slight a-c field at 360 cps.

For various technical applications where the presence of the stray magnetic field is objectionable or where operation in relatively high strength magnetic fields is required, the small size of this basic device makes the use of magnetic shielding practical.

Power Source - This mechanism normally is operated by a self-contained cell capable of supplying power for more than a year. Nominal current at room temperature is 6 microamp. Operating current rises rapidly with temperature due to the characteristics of the transistor and for applications requiring extended operation at high temperature, a

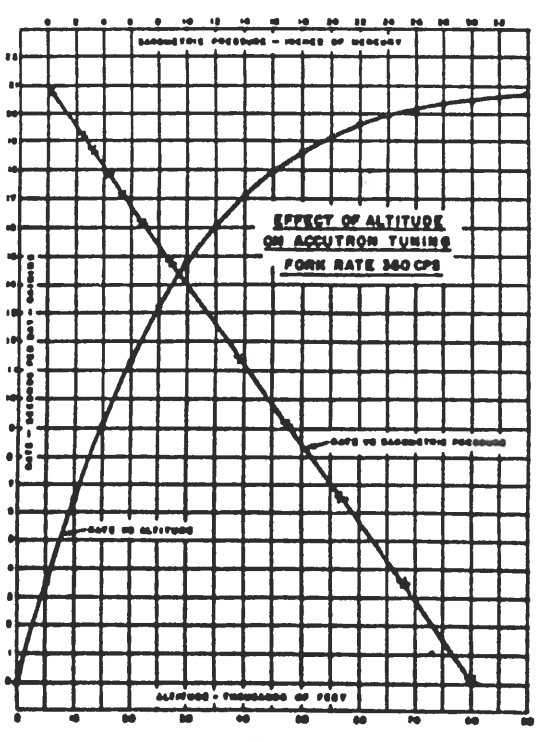


Fig. 9 - Effect of altitude on Accutron tuning fork rate 360 cps

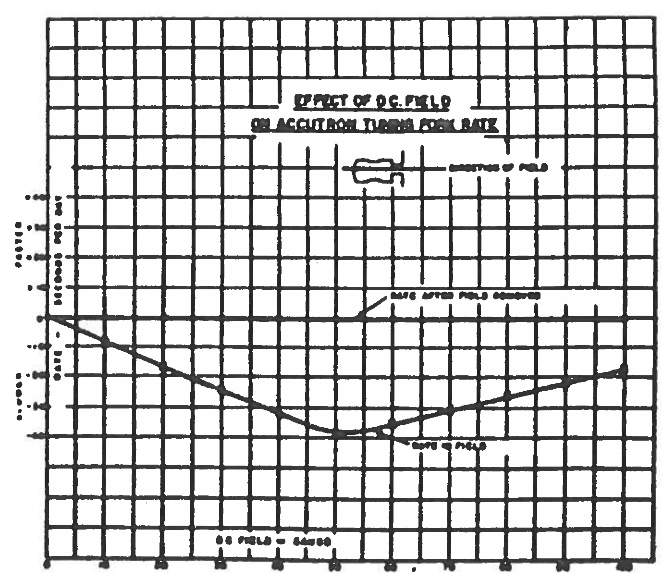


Fig. 10 - Effect of d-c field on Accutron tuning fork rate

silicon transistor must be employed to prevent premature exhaustion of the cell. This device requires a relatively constant 1.3 v d-c from a low resistance source for reliable operation.

Shock - Various devices are employed in the Accutron movement to provide protection from damage by shock. Stops are provided to prevent the tuning fork from being damaged by excessive flexing in any direction and there is a guard around the index and pawl fingers, near the associated jewels, which reduces the tendency of these members to be disturbed by heavy shocks. The effects of shock vary somewhat with direction, nevertheless shocks of the order of a few thousand g's will rarely affect the device.

Starting - Applying electrical power to the circuit driving the tuning fork results in its starting, after a brief delay, if it is not connected to the mechanical indexing system. When loaded by the mechanical system the tuning fork is not self starting; it must be mechanically started by a light tap on the supporting case. In other words, if the device under discussion is used as a chronometric motor, provision must be made to start it, other than the application of electrical energy.

For those applications where repeated starting and stopping are required, the circuit within the device can be altered to permit dropping the mechanical amplitude rapidly to a point at which the indexing mechanism will not operate, or to cause the amplitude to return to its normal operating value, the lower amplitude being obtained by closing an external switch to connect two terminals attached to the device. The "motor" can thus be started or stopped by the usual simple switch, although the device in the stopped condition is not totally inoperative and continues to draw normal current.

Temperature - Circuit elements in the wrist timepiece application of this mechanism are chosen to provide reliable operation from 20-120 F. At lower temperatures the base-current-to-emitter-current gain may, for some transistors, result in failure of the amplitude control circuit to maintain proper tuning fork amplitude. Under such conditions the mechanical indexing system may be unreliable or cease functioning. For special low temperature requirements, use of selected germanium transistors or a reduction of the value of the resistor in the base circuit below its normal value of 3.9 megohms (to increase the height of the base current pulses) can provide reliable operation to -40 F. Below this temperature, the internal resistance of the self-contained mercury cell rises rapidly and it is unsatisfactory as a source of energy.

Above about 130 F unreliable operation can be expected due to excessive changes in the characteristics of the germanium transistor. For wrist timepieces, this upper limit for temperature is not a problem, since the timepiece would be very uncomfortable to the touch if it reached such a temperature. For special high temperature applications, silicon transistors of the PNP type can be employed by suitable alterations in the circuit, providing operation to 210 F.

Fig. 13 shows the performance of a particular tuning fork. Noteworthy is the typical increase in frequency at temperatures below 0 C (32 F) and above 60 C (140 F), although there is negligible change in frequency between these two temperatures. The rise in frequency at extreme temperatures cannot, at present, be avoided.

Torque Output - The following indicates the torque output which can be obtained from the presently designed Accutron mechanism, measured at the center arbor which turns one revoultion per hour:

1. Recommended max torque for accurate timekeeping and continuous operation for minimum one year operation on self-contained cell -- 0.07 oz in.

2. Estimated max torque for reliable continuous operation -- accurate timekeeping not required -- 0.42 oz in.

3. Stall torque -- 0.75 oz in.

The above values may be compared with the torque sup-

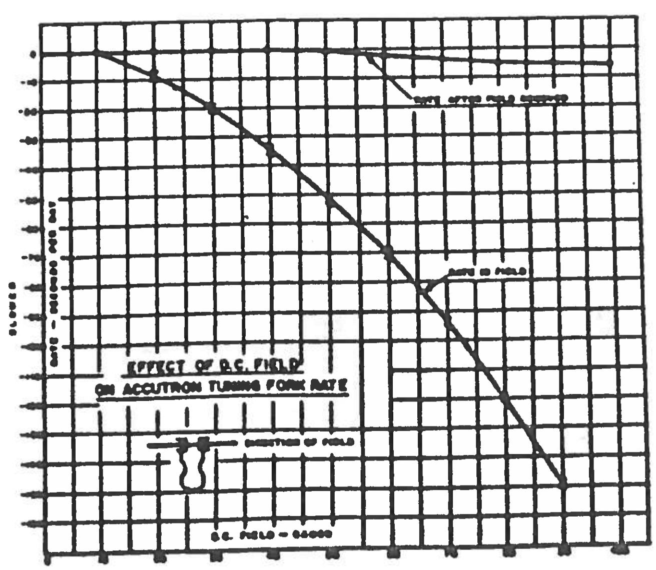


Fig. 11 - Effect of d-c field on Accutron tuning fork rate

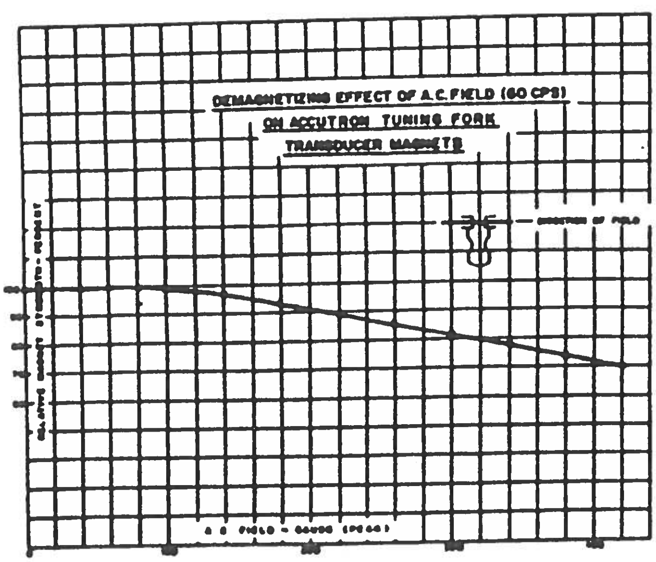


Fig. 12 - Demagnetizing effect of a-c field (60 cps) on Accutron tuning fork transducer magnets

plied by the mainspring to the center arbor of a conventional man's wrist watch movement approximately the size of the Accutron movement. This torque is 0.14 oz in., only a small fraction of which could be delivered to perform useful work, if it were desired to use the watch movement as a chronometric motor. Also of interest is the relatively high efficiency of the Accutron mechanism as a motor. Operating at 0.42 oz in. torque output, the electrical input is 21.6 microwatts. The efficiency is 24%, as compared with 0.1-0.2% for typical small synchronous motors requiring from 0.5-2 w and used for operating time switches, elapsed time meters, and so forth.

The timekeeping properties of the Accutron mechanism, used as a chronometric motor, are affected by the mechanical load applied. Accuracy is relatively unaffected below .07 oz in. torque output. However, at 0.42 oz in. output the rate is approximately 50 sec/day faster than at no load. Obviously, a redesigned movement with a substantially larger tuning fork would be required to deliver relatively large amounts of torque without significant change in tuning fork frequency.

Vibration - This tuning fork based device must be provided with vibration isolation if reliable operation is required under conditions which include vibration. Used as a wrist timepiece, the wrist of the user provides this isolation, the most violent vibrations from power tools and other sources being absorbed by the user's body and not transmitted to the timepiece. At frequencies up to 100 cps, 20 g's can be tolerated by the device without significant effect. At 150 cycles, the limit is about 10 g's, and at 200 cycles the device will not operate reliably above 2 g's. It is not damaged by 100 g's at 5-2000 cps sinusoidal vibration and will resume proper functioning upon removal from the vibration environment. Under such vibration the indexing mechanism causes the output shaft to advance at an abnormal rate and the device may operate at many times its normal output speed.

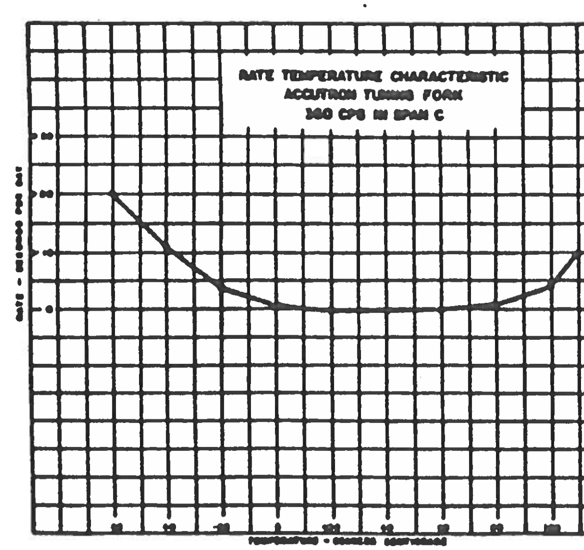


Fig. 13 - Rate temperature characteristic Accutron tuning fork 360 cps Ni Span C

APPLICATIONS OF ACCUTRON MECHANISM

Previous sections have outlined the operation of the present Accutron movement, its operating characteristics, and its reaction to abnormal environmental conditions. For technical applications this device is most useful when time accuracy, small size, and low operating current are important, and where low output shaft speed and torque are not objectionable.

One example of an application employing this device is shown on Fig. 14. This shows a time switch mechanism, driven by an Accutron movement. This device can be preset to provide a double pole double throw switch function at any time from two months to five years after setting. A self-contained cell provides the necessary operating power.

A larger, more powerful Accutron mechanism is under consideration for future production. At present, however, it is not obvious that the range of applications of the basic mechanism would be greatly expanded by the substantial increase in size and power input requirements which would, of necessity, result from, say, a hundredfold increase in output power. Furthermore, such larger mechanism would not necessarily be able to withstand the effects of abnormal environmental conditions better than the present small device. The present mechanism, however, is easily damaged in the uncased condition and adjustment and handling of the basic device should be performed only by a skilled watchmaker. Furthermore, provision must be made in any device driven by the present movement, to avoid forcing the output shaft ahead or back, once cased and ready for use. This requires special attention to setting devices for hands or switches, although in most instances careful design can avoid troubles resulting from forcing the Accutron movement during setting.

This device, in its present form, was developed for one primary purpose -- for use as a wrist timepiece. As designed, it has found many uses as a low speed chronometric motor. A broad line of Accutron mechanisms to fill a variety of future needs for more power, better accuracy, lower cost, and many other requirements will undoubtedly evolve in the future.

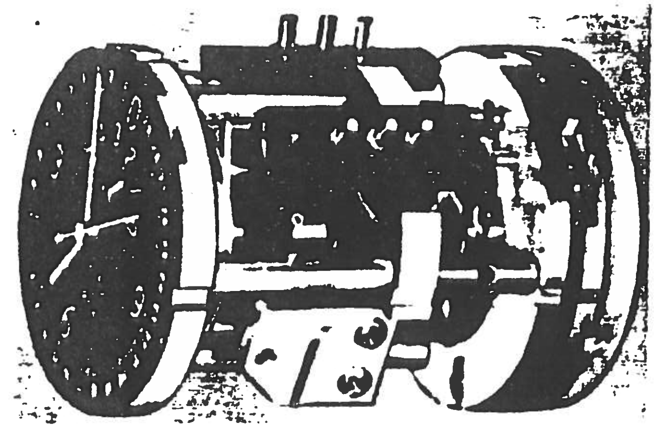
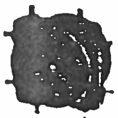
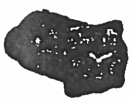


Fig. 14 - Accutron based five year time switch mechanism

Clocks, timers and switches based on the ACCUTRON® mechanism

ITEM	MODEL TE-	DESCRIPTION
 CLOCK 1 In. Dial	10	Basically a timepiece, featuring a 24-hour dial with coaxial hour, minute and second hands. For use in data recording devices, aerial cameras and instrumentation when power is not readily available.
 CYCLE TIMER	11	A Cyclical Timer that features one or more contact closures which can be set in combination at either the same or different speeds of either 1 revolution per minute, 1 per hour or 1 per 12 or 24 hours.
 5 YEAR SWITCH (2 mo.-5 yr.)	12	A Delay Switch Timer providing contact closure from 5 days to 5 years. Dial face shows graduations indicating time remaining. Used in satellites, etc. where space, weight and power are at premium.
 CLOCK 1⅞ In. Dial	13	Like TE-10, but larger dial face. Options: Front setting, stop-start features; 1-31 day calendar, or 0-999 day display with 24-hour dial. Cycle time closure provides closures at specific intervals. Can be externally powered.
 CALENDAR CLOCK	14	Has 24-hour display dial with 1-31 day date, with hour, minute and sweep second hands. Options as in Model TE-13 Series. Ideally suited for remote or unattended areas, and where no power source is available.
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--- MART ---

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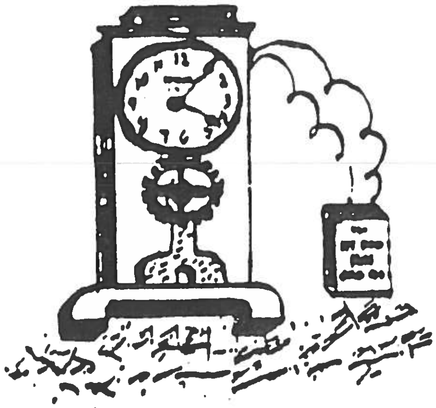
ELECTRICAL HOROLOGY SOCIETY

Chapter No 78



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The Electrical Horology Society--Chapter 78 was formed in 1972 to provide a means whereby members of the NAWCC who have a primary and strong interest in early battery clocks as well as A.C. clocks would have a means to meet and communicate with other members having similar interests. Due to the geographic locations of the membership, our Chapter's cohesiveness depends upon two factors. One, we print the JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY 4 times per year with a yearly total of 72+pages of material. The JOURNAL includes technical information, original articles, reprints of important articles found in sources not generally available to the average collector, a question and answer section, a mart and other pertinent information. Secondly, we encourage groups of members to meet and form "Branches" of our Chapter. Local branch meetings include an educational program, a trouble-shooting discussion and often a small mart.

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NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

The
JOURNAL
OF THE
ELECTRICAL HOROLOGY SOCIETY
Chapter No 78

NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

VOLUME XVII, #2, MAY 1991

Fellow Horologists:

In this, our second issue of 1991, we include a pocket diary and calendar to enable each of us to keep track of meetings and other important data. This was supposed to be included with the first issue of the year but the supplier ran into problems and we were unavoidably delayed. We received an appropriate price adjustment to make up for the tardiness, so all is not lost...

This issue contains a letter dated July 19, 1965 from HOWARD Clock Repair & Maintenance to a school regarding repair prices. We have deleted names to avoid potential embarrassment, but call your attention to the prices quoted more than 25 years ago! (And we get complaints today at quotations LOWER than those of yesteryear)

Charles Aked has provided us with another fascinating article titled, "IMPROVEMENTS TO ASTRONOMICAL CLOCKS" and has included his penetrating commentary, written in his own uniquely entertaining fashion. It seems that the problems with electrical contacts were as troublesome to the scientific community then as they were in the early portion of this century, at least until diodes applied to arc suppression provided a solution.

We are indebted to member, Mel Kaye, for the material on HERSCHEDE Electrically Wound Chime & Strike Clocks. The covers to this booklet were in such poor condition as to defy duplication, but the balance of the material is duplicated in quite legible fashion and should prove quite useful.

Who isn't familiar with the STANDARD ELECTRIC Master Clocks that were so prevalent during the first half of the 1900's? Now look at what has happened when state-of-the-art technology is applied to a Master Clock System. The new owners, FARADAY INC., are continuing in the Master Clock System supply business, and can supply the program tapes for the older models, we are advised.

Good reading ahead...

Martin Swetsky, FNAWCC, President
Harvey Schmidt
Dr. George Feinstein — Co-Editors

HOWARD
CLOCK REPAIRS & MAINTENANCE

1600 PARKER STREET
BRONX 62, N. Y.

July 19, 1965

The Board of Education

Dear Mr.

Sorry for the delay in answering your letter as we have been out of town.

The charges to service your system will be as follows:

Clean Master Clock..........$68.50
Clean Program Instrument....$52.50
Clean Secondary Clocks......$12.00
(parts are not included in prices)

The cost of parts are as follows:

Platinum contacts...........$24.00 a pair
Tapes.......................$ 6.50 ea
Silver relay contacts.......$ 4.00 ea
Winding wheel...............$ 6.50 ea
450 ohm coils...............$ 8.50 ea
Shift pawl (large)..........$ 4.50 ea
" " (small)..........$ 3.50 ea

We await your reply for this work to be done while we are in your area, prior to the beginning of the new school semester. Thank you for your letter!!!

Yours very truly,

OK. Order.

JFR/df

letter sent Aug 4. 1965

IMPROVEMENTS TO ASTRONOMICAL CLOCKS

In 1878 the British Association for the Advancement of Science appointed a committee to consider the problem of devising improvements to astronomical clocks, the members of the committee being Mr. David Gill, Professor G. Forbes, Mr. Howard Grubb and Mr. C.H. Gimingham. The first-named was the author of the first report delivered to the 1879 meeting of the British Association at Sheffield, which for some reason the author requested that it should not be published in the Report of the British Association for 1879.

As a first premise the Committee met to consider the requirements for perfect timekeeping and formulated the following:

> "To maintain the motion of a free pendulum in a uniform arc, when the pendulum is kept in a uniform pressure and temperature, and to record the number of vibrations which the pendulum performs, is to realise the conditions which constitute a perfect clock".

This is probably one of the earliest references to a free pendulum, although others had hinted at it previously by quoting such statements as "the less the motion of the pendulum is interfered with, the better its performance". Since the perfect clock needs to have the pendulum maintained from some external source, not only do the stated conditions have to be met, the maintenance of a uniform arc implies uniformity of impulse to the pendulum, and this latter condition is one that occupied clockmakers for centuries and was never achieved by mechanical means over long periods of time. Thus the report immediately goes on to describe an arrangement it was hopeful would bring about the desired result:

The conditions of absolute uniformity of impulse arc, with one exception, are realised in the following arrangement. Let S be the point of suspension of a pendulum and P the pendulum rod (Figs 1, 2, and 3). Let W be an impulse-piece of the shape shown, suspended by a very delicate spring, so as to swing accurately from the same centre as the pendulum. M is an electro-magnet, N an armature mounted on an arm A which is pivoted at Q.

In Fig. 1 the pendulum is supposed at rest; but the armature N, and the arm A are drawn, as they cannot remain, for A must either be pulled against the banking pin p by the spiral spring R, or against p2, by the attraction of the electro-magnet M.

Let us now suppose that matters are so arranged that when the impulse-piece W acts on the pendulum, a galvanic circuit is completed, and M becomes a magnet, we shall then have the position of the arm A, and of the impulse arm W, as in Fig. 3, and when the impulse weight and pendulum rod are separated, we shall then have the position of these as shown in Fig. 2.

Now let us follow the action of this escapement.

First suppose the battery to be attached when matters are in the position shown in Fig. 1. The effect will be that the arm A will be drawn against p2. If we now set the pendulum swinging to the right the impulse arm W will follow the pendulum as far as the arm A will allow it to do so, but on reaching this limit, the pendulum will leave the impulse arm and continue to swing to the right alone.

The instant, however, that the contact between W and P is thus broken, M is no longer an electro-magnet, and the arm A is drawn by the spiral spring to the position of Fig. 2; the pendulum continues its swing to the right, comes to rest, and returns. On its return it encounters the impulse-piece W, not where it left it (viz at its lower limits, the arm resting on p2), but as in Fig. 2, the arm A resting on p1. When P and W encounter, the immediate result is that, contact being formed, M becomes a magnet, and the arm A is drawn against p2, whilst the impulse-piece W continues its motion towards the left, along with the pendulum, and returns again to the right with the pendulum till it is stopped by encountering the arm A pressing against p2.

Simply stated, the impulse is this: The pendulum in swinging against the impulse-weight picks it up at p1, and in swinging with the impulse-weight it carries it on past p1 as far as p2. The effective impulse is therefore, that of the fall of the resolved horizontal force of W in falling from p1 to p2.

This force is absolutely constant.

There is no locking or unlocking, and no friction, and no element of change except such as may be due to the electric contact between W and P. Such contacts are liable to wear and to stick, and it was not until some prospect offered of overcoming this fault that we ventured to request a grant from the Association. The plan of escapement had already been contrived and tried experimentally by Mr. Gill; but it was in consequence of an idea of Mr. Gimingham's that it first seemed possible to overcome the outstanding difficulty and attain a nearer approach to perfection.

Mr. Gimingham's idea was to construct a relay which could be worked by radiation. This relay he first contrived for the purpose of registering the number of revolutions of a radiometer.

The form which this relay has now assumed, after a variety of experiments, is shown in Fig. 4.

K is a very light arm of aluminium, mounted on needle-points.
B is a fan of mica, coated on one side with lampblack.
C is a carbon point attached to K.
By means of an aluminium ring r, fitting spring-tight into a glass tube, the supports of the needle-points of K are fixed in postion - the supports being attached to the ring.
Another ring t, carries a small carbon anvil, against which the carbon point C can come into contact.

Two platinum wires, in connection with r and t respectively, are fixed into opposite ends of the tube. The tube is then exhausted till a Crookes' vacuum is obtained, when the arm K becomes a radiometer arm. A small slip of magnetised watch-spring is attached to B, so that a fixed magnet can be so placed as just to bring the carbon point and anvil in direct contact. A strong light being then turned on B, the screen acts like a radiometer arm, moves back, separates the carbon points, and contact is broken.

By attaching a simple screen to the pendulum, it therefore becomes possible to cause the pendulum, by alternating, to admit and cut off light from B, and so produce alternate make and break, entirely as required by the escapement, without employing any actual contact on the pendulum. The chief difficulty we now find is a tendency of the carbon points to stick, and some experiments are now being made relative to this matter.

Four relays on the principle described have been constructed and are in the hands of the committee for experiment, and Mr. Gill has, besides, a model of the escapement, and a pendulum with which experiments are being carried out.s A sum of £12.12s. has been expended out of the grant of £30, and the Committee requests that the balance of the grant should be allowed to be applied to the same research.

Second Report

Since the foregoing report was sent from the Cape by Mr. Gill, I have devoted much time in developing the mode of electric contact-making by radiation. In the above report for last year is described a form of the radio-relay which at the time seemed to give the most promising results of any that I had tried. Four of these were made, as mentioned by Mr. Gill, one of which he took out to the Cape, experimented with, and in the report he mentions the the chief difficulty as being that of the tendency of the contacts to stick together when work is being done by the current.

In the case of using contacts of metal, such as platinum, this difficulty is insurmountable, for the reason that the power required to separate the contacts when once closed is far greater than that which can be obtained from any source of radiation that could be used for our purpose. This point I had settled some time back, and had almost abandoned the idea of success, when the discovery of the microphone by Professor Hughes suggested to me the idea of using carbon contacts. I then commenced working on the subject again, and experimented with a great number of instruments of different forms.

The form of a pendulum with the contacts near the point of suspension has at present given the most satisfactory results. Figure 5 represents the pendulum form of the radio-relay; a is a strip of moderately thin aluminium, to the lower end of which is attached a plate of silver flake mica b, blackened on the outer face; c is a clear mica screen, the same size as the plate b, also attached to the lower end of a, enclosing a space of about 6 mm. between the two plates.

The strip of aluminium a is suspended by two springs of soft iron wire, beaten out flat and very thin in the centre, represented by d in section and d d' in elevation. The springs are in metallic connection with the platinum wire e, which is hermetically sealed through the tube A. To the other platinum wire f, the inner end of which is beaten out into a thin spring, is attached a carbon point g, h being the corresponding carbon plate attached to the pendulum, just below the suspension springs. The whole is enclosed in the tube A, which is expanded into a bulb at the lower end, exhausted from the end B, and hermetically sealed.

On placing a source of radiation in front of the blackened surface b, and allowing a screen to move to and fro between the source of radiation and the bulb, contact will be alternately made and broken between the carbons g and h. In order to give an idea of the amount of radiating force required to produce a Crookes' pressure of sufficient power to work an instrument of this kind, I will mention that a candle placed four or five inches off the bulb, with a concave reflector at the back, answers exceedingly well, providing the surface b is about $1\frac{1}{2}$ square inches in area. The actual effective force also depends to a great extent upon the distance between the surface b and the glass envelope. For this reason I have tried using a clear mica screen, placed inside the bulb very close to the black surface; but although theory would indicate the advisability of so doing, practice shows that very little advantage is gained by the introduction of such a screen, the fact being partially accounted for by its forming a second obstruction to the radiant force from the light used to work the relay.

By the introduction of carbon contacts I had hoped to have entirely avoided their sticking together when the current passed. Although for all practical purposes their employment together with the pendulum form of instrument has sufficiently reduced this sticking, yet to a certain extent it still remains a drawback to the use of such a delicate force for making contact as that to be obtained from this indirect action of the radiation from a small lamp or candle.

When the contacts merely pass the current through a short length of straight wire, there is little or no sticking, but on the introduction of an electro-magnet, a bright spark passes between the contacts, and sticking occurs. The spark is well known to be due to the discharge of the extra currents set up in the coils of the magnet, and I expected that both the spark and the sticking would disappear on attaching a tin-foil condenser to the terminals of the relay. On trying this experiment the spark was reduced, but there was no observable alteration in the sticking.

This sticking is probably due either to the carbon containing a fusible ash, or the attraction of the two large surfaces of oppositely charged carbon, large compared with the part that absolutely touches and through which only part of the current would be passing. I have tried several kinds of carbon for the contacts, but the finest electric-lamp carbon seems to be the only available sort, the resistance of more compact carbons being too high. I have also tried using contacts of platinum, iridium, also one of platinum and the other of gold, platinum and iridium, carbon and platinum, all of which stick together more than when both are carbon.

In order to overcome the, for the present, inevitable amount of sticking of the carbon contacts, it is necessary to multiply the force for making and breaking contact by means of long leverage. It will be seen that in the pendulum arrangement described, any amount of leverage can be easily obtained without the friction or resistance that would be caused by pivots.

The force also, obtainable from a given source of radiation, is greatly augment in this instrument by the use of a screen placed a little distance behind the blackened surface, but fixed to it as part of the pendulum bob. In this way nearly the maximum amount of Crookes' pressure is obtained, all acting in the one direction, whereas, if there be no screen behind the black surface, the heat transmitted through the blackened mica sets up a considerable Crookes' pressure, which acts between the bulb and the back of the blackened mica, considerably reducing the effective force in front.

In experimenting with these various radio-relays, I have used a seconds pendulum, having an escapement similar to that described by Mr. Gill in his report for last year.

It has been necessary to use an ordinary, but very sensitive, relay between the radio-relay and the pendulum, as it is best to have as weak a current as possible passing through the carbon contacts.

I regret that my experiments in the radio-relay part of the subject should have extended over such a long period, but the time I have at my disposal for original work is very limited.

I also regret that I cannot be present at the meeting this year, to show the various relays, and receive suggestions from the members of Section A. I shall, however, carefully study any discussion that may be recorded on the subject, and in the continuation of the experiments make use of any suggestions with great pleasure.

C. H. GIMINGHAM.

Dear Mr. Gimingham, - I return you herewith Mr. Gill's letter and diagrams. The principle of his proposed arrangement seems admirable, provided a perfect system of contacts could be devised, and your plan for them is unexceptionable in theory; but as it appears that the carrying out of the details may be a little troublesome, I have had recourse for the present to a more simple contrivance, which, though not so perfect theoretically, will, I believe, be found to work very well in practice.

I annex a figure (Figure 6) which represents the arrangement. A very small magnetised needle A A is pivoted as a compass needle on a vertical pin b. In a plane above or below this is pivoted a light forked lever d d d so placed that a pin c in the magnetised needle, hits one or other of the prongs of the fork d d as it swings from side to side. At the extreme end of the lever d is fixed a fine fibre of spun glass slightly buckled by the screw t; this has the effect of putting the forked lever d d into a state of unstable equilibrium and compelling it to keep in contact with one or other of the contact screws s s'. The whole apparatus is enclosed in an exhausted glass tube (to prevent oxidation of the gold contacts) and when required for use is placed in the clock case just below the iron bob of the pendulum.

As the pendulum swings the magnet answers to its motion, and draws the forked lever into contact with either of the screws s s' which are tipped with gold. The buckling of the glass fibre tends to make the contact very certain and avoids any danger of recoil, while there being no oxygen left in the tube, there can of course be no oxidation of the contacts.

It is supposed that the clock has a mercurial pendulum with cast-iron cistern, as most pendulums are now made.

The above arrangement is not theoretically perfect, for there must be some s slight reaction from the magnet to the pendulum; but as the pendulum weighs, or should weigh, about forty pounds and the magnet about ten grains, the reaction must be very slight, and even this would be of no consequence provided the magnetisation of the needle remained constant.

The convenience of the arrangement, and the ease with which it can be applied without interfering or tampering with the clock, commends it for practical work.

The only practical fault I see in Mr. Gill's arrangement for driving the pendulum, is the extremely small travel which the impulse lever has in each impulse. This will necessitate very perfect 'banking' arrangements, for a very small difference in this travel will make a large difference in the impulse on the pendulum, and the perfection of the arrangement depends on the impulse being a constant. It appears to me that it would be desirable to make the impulse-arm very light, but longer in its travel, and acting perhaps farther down on the pendulum rod.

These are the only points that occur to me.

Faithfully yours,

HOWARD GRUBB.

Dublin: August 23, 1880.

NOTES: David Gill, according to Frank Hope-Jones, was apprenticed as a clockmaker to the well-known Clerkenwell firm of Messrs. R. Haswell & Sons but this seems strange in view of the career and circumstances of Gill's life. He was born 12 June 1843 at 48 Skene Terrace, Aberdeen, the eldest son of David Gill who had married Margaret Mitchell. The father was a watchmaker with a well-established business in Aberdeen. Gill was educated at Aberdeen University and came under the influence of the great Clerk Maxwell. At his father's desire Gill entered the business and for a time had complete charge of it, mastering all the work, and in fact made a clock which he kept to the end of his days; nevertheless in 1863 he became active in astronomy as a result of an introduction to Charles Piazzi Smyth when he was shown round the Edinburgh Observatory and the arrangements for the time-gun and ball. It had occurred to Gill that a time service might be useful in Aberdeen similar to that introduced by Piazza Smyth in Edinburgh, hence his visit in 1863. With the help of Professor David Thomson, Gill re-established the disused observatory of King's College, Aberdeen, discovered a small transit instrument, added a mean solar clock controlled to a fraction of a second of Greenwich time, and added contact arrangements to give electrical control of King's College turret clock and the other public clocks in the town. After acquiring a telescope, Gill made a driving-clock to the design of Airy's chronograph at Greenwich which he maintained gave the best performance of any clock. He married Isobel Black, a farmer's daughter, in 1870. Shortly afterwards he was offered the superintendence of the private observatory erected by Lord Lindsay at Dunecht (1872), and visited many of the European observatories, meeting most of the leading astronomers. Lindsay and Gill were invited to take part in the transit of Venus observations in 1874, and in order to establish the accurate longitude at Mauritius, Gill hired fifty marine chronometers from the best makers, took them to Greenwich for rating, and on departing from England, left Airy and his staff amazed at the audaciousness of his action. The Mauritius trip was a great success and Gill returned to England without a single mishap to the chronometers.

After several more expeditions, Gill was appointed H.M. Astronomer at the Cape of Good Hope which had been founded in 1822 by the Lords Commissioners of the Admiralty for observational work for the special benefit of navigators, this was in 1879, the year following the formation of the British Association Committee to determine means of improving astronomical clocks. Gill's greatest contribution was the development of photographic techniques in charting the stars and heavenly bodies, he was knighted in 1900 to become Sir David Gill, leaving the Cape Observatory in 1907 to return to England where he became President of the Royal Astronomical Observatory from 1910-1912. He passed away in London on 24 January 1914 following an attack of pneumonia. Professor G. Forbes wrote Gill's biography entitled David Gill, Man and Astronomer, published in 1916. Sir David himself wrote a book on his work at the Cape Observatory - History and Description of the Royal Observatory of the Cape of Good Hope, 1913. His portrait was painted in 1912 by George Henry (Royal Academy pictures 1912). Although he had no family himself, he brought up the orphaned sons of his brother as his own.

From all accounts it seems that Gill's astronomical clock never achieved success, although later it was placed in a vacuum chamber and surrounded by a water bath to maintain a constant temperature. Frank Hope-Jones states in his Electric Clocks and following volumes that much money was spent upon it, but as the reader can see for himself, the British Association grant was only £30, and there was never a great deal of money to spare at the Cape Observatory, in fact Gill borrowed or supplied some of the essential instruments himself in his early days. Gill's method of impulsing the pendulum was not new, as Hope-Jones himself implies after first deriding Shepherd's escapement and then faintly praising Froment's pendulum as better than the later one of Gill. However Alexander Bain had long before included the method in his patent, he was the first to suggest the use of a spring charged by an electro-magnet. Hope-Jones goes on to say that Gill's was a perfect solution except for the contacts whose reliability was doubtful, which Gill had commented upon in any case and had attempted to remove the contacts from the pendulum completely. With the contacts on the pendulum, the energy for impulsing the pendulum is transmitted through the contacts mechanically, which Hope-Jones endorses, going on to enquire where the energy come from to operate the contacts. Not from the pendulum he asserts but transmitted through the surface of the contacts in the act of driving the pendulum. A moment's reflection will show that this statement is pure rubbish because the pendulum contact has to meet the contact of the spring tensioned arm and has then to raise the arm against the full impulse force until the pendulum reverses its swing, the energisation of the magnet not contributing any energy towards this action, if the electromagnet received no current, the amount of energy abstracted from the pendulum would be exactly the same. As soon as the pendulum reverses, the spring tensioned arm hands back the energy until it reaches the point at which it was picked up, less frictional losses, and from that point until the arm reaches the pivoted arm stop, extra energy is supplied to maintain the pendulum in motion, at which point the contacts open, the magnet de-energises and the spring tensioned arm is lifted. The work of separating the contacts also comes from the pendulum and this is a variable amount deducted in accordance with the state of the two separating surfaces. Of course the energy ultimately comes from the energy supplied by the electromagnet lifting the arm, but it flows in and out of the pendulum in the act of initiating the impulse sequence.

The contact pressure with such a light arm is very low and the imperfect contact action is the cause of the current being partially interrupted, causing deterioration of the contact surfaces by pitting through the very high current density at the high spots burning and oxidising. In contrast Hope-Jones' system transmits mechanical force from the attraction of the soft iron armature through the contacts against a large mechanical mass, the contact action is rapid by the swiftly moving mass falling and closing the contacts, with an equally rapid opening as the accelerated mass leaves the armature contact behind as it halted by its stop. The contact pressure is exceedingly high compared to that in contact systems such as Gill's, and the pendulum is not involved in the action whatsoever.

The discussion about the contacts however is academic since contacts operated directly by the pendulum were early abandoned by Gill and ended in this report with a relay operating the electromagnet and switched by a radiometer actuated by a light shining through a slit carried by the pendulum. Just how the impulse was then given to the pendulum is not given, however it would seem that this method would give an opportunity to avoid the asymmetrical action of the first system of impulsing and arrange an impulse centred near the middle of the pendulum swing. Possibly with a very heavy pendulum bob the lop-sided action would be minimised in effect. Nevertheless there is no fundamental reason why the original arrangement could not function well if the effect of the electromagnet field collapse could have been bypassed from the contacts, a capacitor alone was not enough as Gill found, perhaps this produced an oscillatory current, and the addition of a resistance to increase the losses might have succeeded. A slugged electromagnet would have been beneficial, or today a "flywheel" diode across the coil would remove all the induced high voltage away from the contacts which Gill found so troublesome, and eliminate the corrosion and sticking resulting from the sparking at the surfaces.

Gill did not consider the extraction of energy from the pendulum, he merely considered the effective impulse given by the impulse arm descending to a lowe level with the pendulum swing than against it. His attitude that the contacts were liable to wear and to sticking and a fault in the design would not allow him to request a grant until he thought that these could possibly be dispensed with following a suggestion by Mr. Gimingham.

Mr., later Sir Howard Grubb, became a Fellow of the Royal Society and a Vice-President of the Royal Society Dublin. He was much interested in electric clocks and read one paper on the subject of the control of electric clocks for driving equatorial telescopes to the Institution of Mechanical Engineers at Dublin in July 1888. He mentions this in a paper read to the Dublin Royal Society 17 January 1905, when he stated that his system was adopted for the International Photographic survey of the heavens by the observatories at Greenwich and Capetown amongst many others, and found to be capable of driving with the necessary accuracy and to be reliable so long as the electrical contacts were maintained in good condition.

Professor G. Forbes (1849-1936), as mentioned earlier, wrote the definitive biography of Sir David Gill from personal knowledge. He was an English physicist and invented the carbon brush for dynamos, as well as assisting James Young to improve the method of measuring the velocity of light at Pitlochry in Scotland from 1878 onwards. Although mentioned in the Dictionary of National Biography in several places, he is not included in the entries.

Mr. G. H. Gimingham, given as Mr. Ginningham by Frank Hope-Jones, is even more elusive but he appears to have been a physicist with a good knowledge of electrical engineering.

No doubt there are many other items contained in the British Association for the Advancement of Science Reports which would be of interest to those who wish to know more of the history of electrical horology. The writer has searched a good many years however without finding a great deal of interest in the reports issued in this century. It could be a field for someone wishing to make a contribution to this branch of timekeeping, for it seems to the writer that for too long we have placed the burden of the history of electrical timekeeping upon Hope-Jones alone and we have tended to accept his word and judgement as final. After nearly half a century, the cracks in the edifice are beginning to appear with the uncovering of facts not available to Hope-Jones, and we have hardly scratched the surface compared with the vast amount of material as yet untouched.

Charles K. Aked

22.9.1894

Figures 1 - 3

Page 56 of
Report - 1880

FIG. 1.

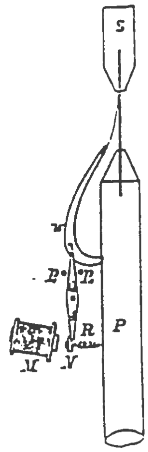


FIG. 2.

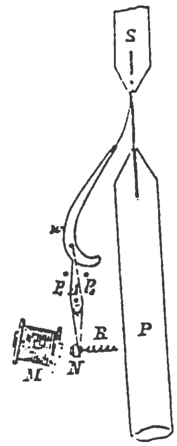


FIG. 3.

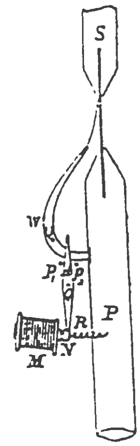
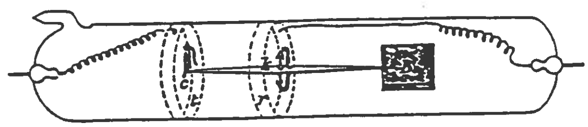


Figure 4

Page 57 of
Report - 1880

FIG. 4.



Figures 5 & 6

Pages 59 & 61 of
Report - 1880

FIG. 5.

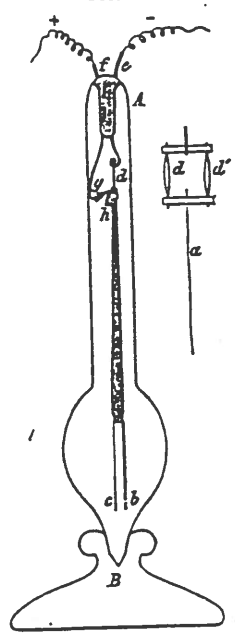
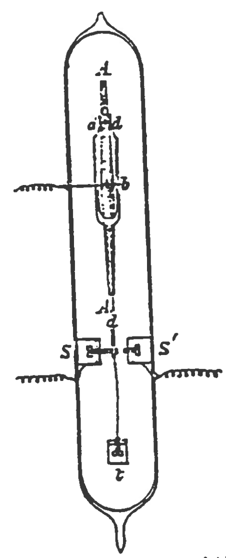


FIG. 6.



Taken from British Association for the Advancement of Science Report of 1880.

There is a standard in everything . . .
Something to judge against . . .
in time it is STANDARD . . .

Standard Electric Time Clock Systems . . .

As with any standard, you would expect it to have been proven — proven by that old standard, the test of time, and that newer standard, technology.

Standard Electric Time was founded in 1884 — just 6 years after Edison invented the electric light.

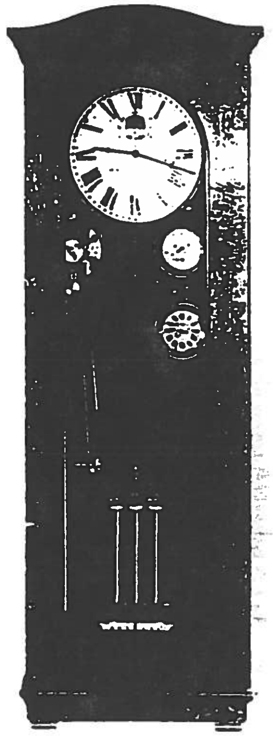
Standard Electric Time was the first to produce an electric clock in the United States.

Standard Electric Time developed the first program time machine in America — over 60 years ago.

Today, Standard Electric Time Systems are manufactured by Faraday, Inc., a technologically based company located in the small town of Tecumseh, Michigan, an area steeped in the traditions of hard work and quality products.

Technically speaking, Standard Master Time Systems are as advanced as current technology can take them, without being overburdened with impossible to understand computerese.

First designed to run clocks in school systems, the Master Time units produced by Faraday now are found in hospitals, stores, airports, banking institutions, government buildings and factories. In fact, anywhere you need accurate time, you are likely to see STANDARD clocks on the wall.

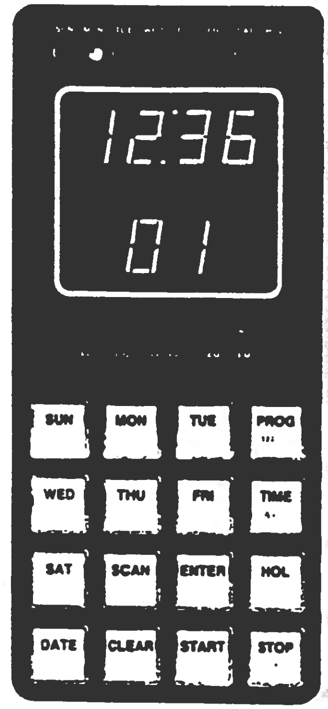


Ease of Operation
You don't have time to be a master technician. Faraday thinks that you should be able to set it, and forget it.

That is why our systems are:
- Microprocessor Based
- Quartz Controlled
- Field Programmable
- Field Expandable.

And Featured as Standard:
- Automatic Daylight Savings and Leap Year adjustment
- Automatic Holiday Programming. . ,and more

Two of these items are especially important to you.



Field Programmability
Look at the keyboard illustrated here.

Notice that everything is in plain english? There are no codes to put in. Push the TIME button and put in the time. Push the DAY button and you have the day. Push the DATE button and . . . Incredibly easy in this day of "state of the art" mumbo jumbo.

Field Expandability
Worried about future requirements? Standard allows *you* to expand the system — not a technician. It features plug in modules, designed for easy installation — even if you're not a whiz kid.

Need to update your system? Standard Systems wouldn't be standard if you couldn't add it to your present system. Whether a master time programmer, or a secondary clock, Standard can work with the components you presently have — it's designed into our program already.

Couple this with the fact that Standard Clock Systems have a Non-volatile Program Memory Circuit, PLUS a battery back-up system, and you have reliability.

How reliable — how about 99.6%! That's dependability.

What else is there to consider?

Price
With our system, you get all the extras for our Standard price. We don't have a long list of options — even the back-up battery is included. Compare us item for item, and you will find that we are also the price standard.

Service
As we stated, Faraday is a company steeped in the work tradition. Call us anytime. We are there to assist if you need us. . . which, 99.6 times out of 100, you won't.

STANDARD Standard Electric Time FARADAY

174 Passaic Ave.
Fairfield, NJ 07006
Phone: (201) 227-9190

INSTRUCTION BOOK

HERSCHEDE

ELECTRICALLY WOUND
CHIME and HOUR STRIKE
CLOCKS

J.E. COLEMAN
Clockmaker

NASHVILLE, TENN.

THE HERSCHEDE HALL CLOCK CO.

CINCINNATI, OHIO

Instruction Book

The Herschede electrically wound chime and strike movements are carefully made by expert clock makers. They are given a thorough inspection and running test in an endeavor to observe the slightest defects in the assembling and adjusting of the movements. Then they are mounted into cases, and another inspection is given to the dial and details of the casing, after which the hammers are adjusted to the chime bars. The movements are then given a final running test in their cases, thoroughly regulated and finally inspected before packing to insure each clock leaving our plant in perfect shape.

While the clocks are in transit it is possible that through extremely rough handling, some of the parts may become disarranged and consequently need some slight adjustments. The retailer is advised to run each clock on test for at least 24 hours providing his place of business is equipped with alternating current. If he has only a convertor to transform the direct current to alternating current he should at least test the chimes and hour strike by turning the hands forward, permitting the chimes to operate at each quarter.

In setting up a Herschede Clock it is necessary to read thoroughly the instructions on the inside of the back door. After the clock is set up the tone of the chimes should be noticed. The chime hammers should be about $\frac{1}{8}$" directly over the center of the chime bar it is to strike. The bars should not touch the chime bar shipping holder and if they do they can be bent slightly at the point of contact with the chime bar holder in the direction desired. All the bars should be in alignment.

The small motor that winds the main spring and operates the chime and strike train runs only on 60 cycle (or the cycle marked on motor) 110 volt alternating current. If the current is shut off the chimes and strike mechanism will not operate but the spring has enough reserve power to run the time train for 24 hours or more. When the current is turned on the motor will wind the spring to its proper tension. Only one-third of the capacity of the motor is ever used. This motor needs never be oiled. The case is hermetically sealed and the gearing is constantly lubricated by the oil in the casing.

Motor shaft turns once a minute and is geared to center wheel Y which also turns once a minute.

Operation of Self-Equalizing Winding Mechanism

Our (patent applied for) self-equalizing main spring winding mechanism is very simple in construction which at no time fully winds the main spring or puts same under an excessive strain and at the same time compensates for any "setting" in main spring.

Operation is as follows: On center wheel bushing 50 is mounted an eccentric 51 which operates winding pawl 52 back and forth once a minute. This slow motion of pawl 52 operates front ratchet wheel 53 the distance of about 1½ teeth. This ratchet wheel 53 being mounted on shaft with rear ratchet wheel 54 turns rear ratchet 1½ teeth same as ratchet 53. On equalizer arm 55 is mounted click 56 which holds ratchet wheel 54 and through pinion 57 the power of the main spring. Onto ratchet wheel 54 is fastened pinion 57 which turns main wheel 58 winding main spring.

Equalizing or Controlling Power of Main Spring

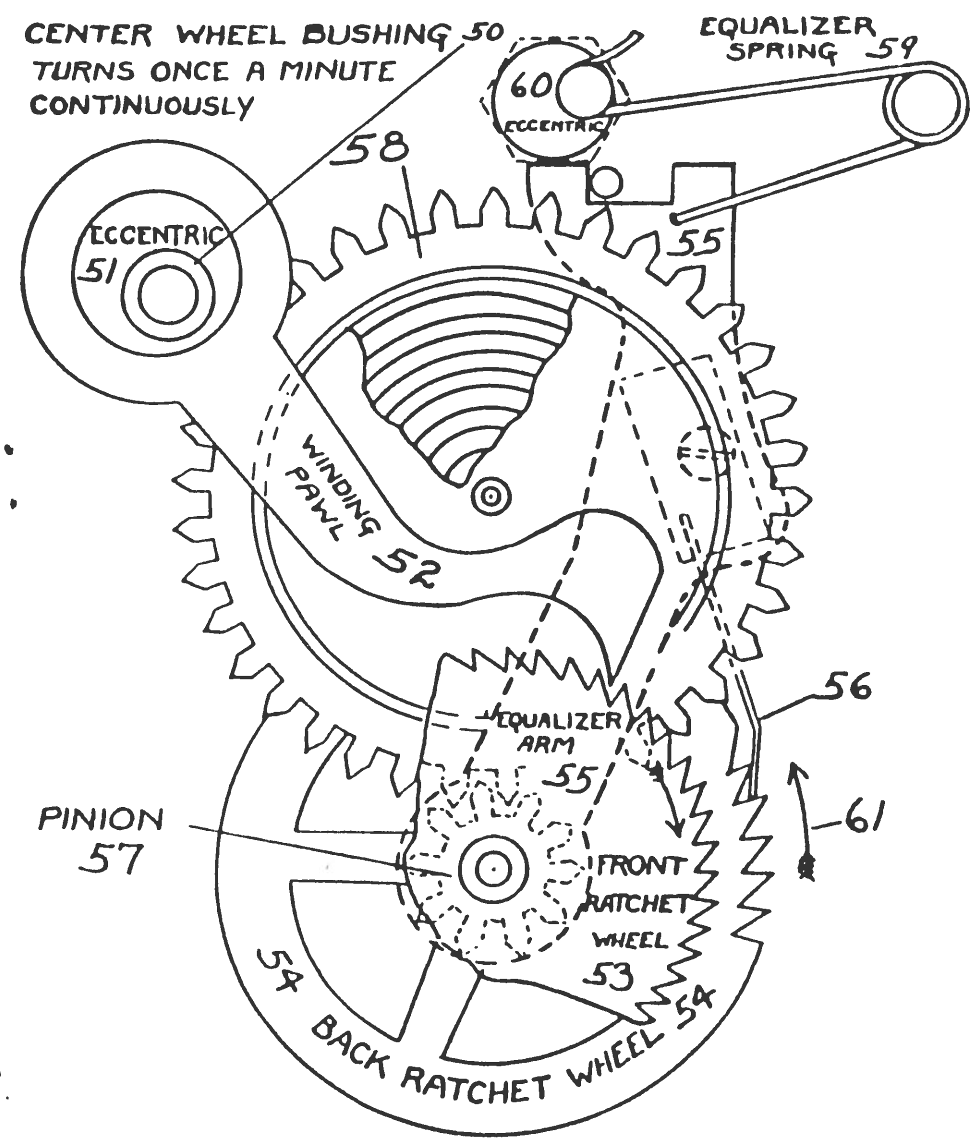
There are 9 turns of main spring in the barrel. Main spring is wound to and equalized at 6 turns which operates time for about 24 hours without current.

On end of equalizer arm 55 is mounted one end of equalizer spring 59, the other end of this spring being fastened to a stud located on an eccentric 60 fastened in the back movement plate.

Eccentric 60 is adjusted at the factory to allow main spring to be wound 6 turns and should not be changed. To equalize at more turns of main spring, eccentric 60 is turned slightly to left and to equalize at less than 6 turns turned slightly to right.

The power of the main spring is carried through ratchet 54, to the ratchet click 56 mounted on equalizer arm 55, the power being greatly reduced at this point, because of the compounding of gears.

When main spring reaches a power equal or greater than equalizer spring 59, main spring backs up ratchet 54 and front ratchet wheel 53 in direction shown by arrow 61, moving equalizer arm 55 to the left, which prevents winding pawl 52 from gathering a tooth, and main spring will not be wound.



When equalizer spring overcomes the power of the main spring, equalizer arm 55 again moves to the right allowing winding pawl 52 to again gather a tooth and wind the main spring.

Main spring is wound about two out of three minutes when movement is in regular operation. Note: For convenience the end of the main spring shaft in the back of the movement has a slot in it and can be wound by using a screw driver, if desired. For convenience, a hole is placed in front plate showing operation of winding pawl 52 and ratchet wheel 53, also in back plate showing ratchet wheel 54 and ratchet click 56.

Explanation of Chime Movement

Chime Control

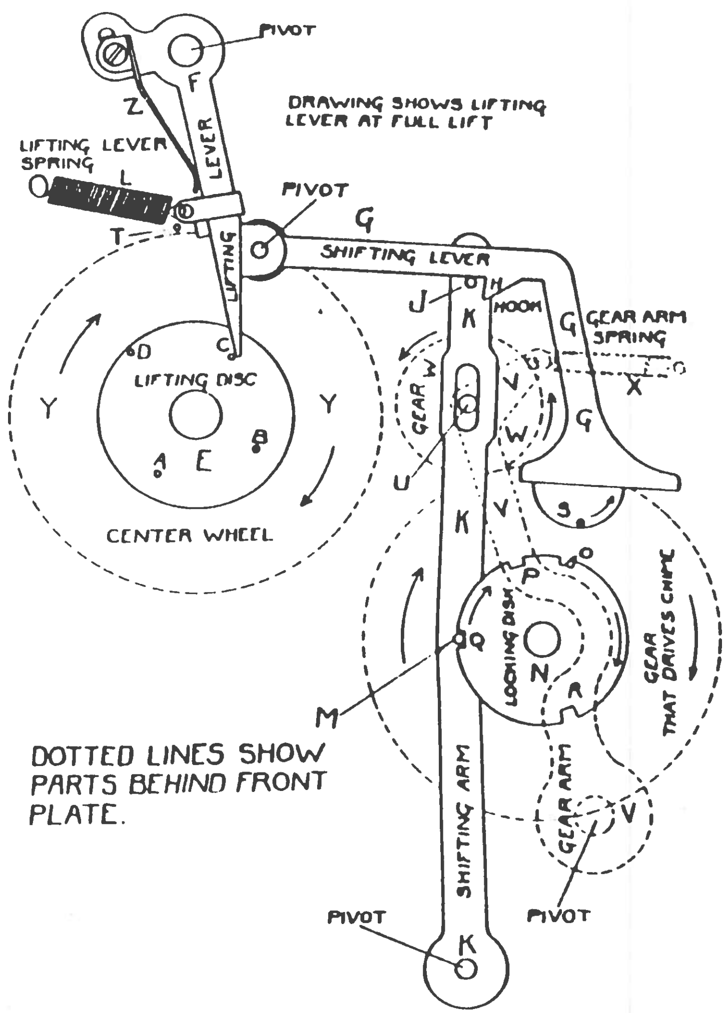
(Right Side of Movement)

The chime is controlled by the four pins, A, B, C, D on the lifting disc "E" which makes 1 R.P.H. A, B, C and D operate the first, second, third and fourth quarter chimes respectively.

These pins move the lifting lever "F" to the right, permitting the shifting lever hook H to drop over pin J on the shifting arm K. The lift should be far enough to permit 1/32" clearance between the pin J and hook H *and each pin should be tested.*

Pin D operates the self-adjusting feature at the hour which will be explained later. If the lift is not enough to afford the above clearance the lifting lever F should be bent slightly to the left and if too much bend to right at the end that comes in contact with the lifting pins, A, B, C and D.

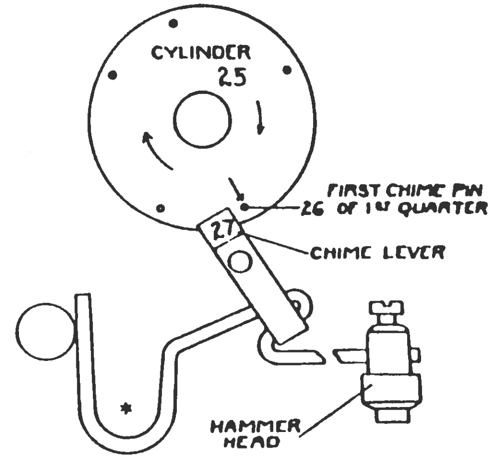
As the lifting lever F drops off one of the pins on the lifting disc E it is pulled back almost to its original position by the small coiled spring L and since the shifting lever G has hooked the shifting arm K by its pin J, the shifting arm K is pulled with it towards the left of the movement. The lower pin M on the shifting arm K is then pulled out of the slot in the locking disc and is held out until the locking disc has turned far enough to be sure that when the shifting lever G is released the pin will *not* drop back again into the same slot but will rest on the circumference of the locking disc N. The shifting lever G is released by the pin S which makes one



revolution for each bar (four notes) chimed and lifts the lever so that the hook H is released from the pin J. The lifting lever will then go completely back to its original position against its banking pin T. When it is in this position the hook H should rest on top of the pin J while the clock is chiming.

The shifting arm K has a double duty. It engages the chime gear arm pin U through its slot; also the lower pin M holds this gear arm gear W into mesh while chiming by resting on the circumference of locking disc N. There should be slight play between the locking disc N and pin M. The locking disc turns as the chimes operate and as the slots come into position the pin M will drop and the gear W on gear arm V, is pulled out of mesh by the coiled spring X attached to it on inside of movement plate. This spring should be just strong enough to safely disengage the gear W from the center wheel Y. The lift lever spring L must be strong enough to safely pull the chime gear arm gear W into mesh but must not be so strong that the main spring will not have enough power to operate the lifting lever F through the pins A, B, C and D on the lifting disc E which is fastened to the center shaft 10. If the gear arm spring X is too weak the gears will not come out of mesh and the clock will continue to chime. If the gear arm spring X is stronger than the lifting lever spring L it will resist the lift lever spring L and Pin M will not be completely pulled out of the slot in the locking disc and as the gears are in mesh the disc will turn, and bind itself on pin M and the clock will stop.

The locking disc N determines the proper quarters on the chimes by the distance between the slots. Three of these slots, O, P, Q are the same depth. These three represent the first, second and third quarter chimes respectively. The fourth or deep slot R represents the hour or fourth quarter chime. When the pin M of the shifting arm K is in the slot R it takes a longer movement of the lifting lever F to disengage it from the slot than it does to disengage the pin M from slots O, P, Q. Pins A, B, C on the lifting disc will disengage the shift arm pin M from the three quarter slots O, P, Q, but will not disengage it if it is in the deep or hour slot R. The hour pin D because of its position on the lifting disc has a longer throw and is the only pin that will permit the shifting lever hook H to drop behind the pin J when pin M is in the hour or deep slot on locking disc. This is the self-adjusting feature as the four quarter bars will only chime at the hour.



CORRECT POSITION OF CYLINDER PINS IN RELATION TO CHIME LEVER 27

* Important: Do not bend this lever

Setting Cylinder

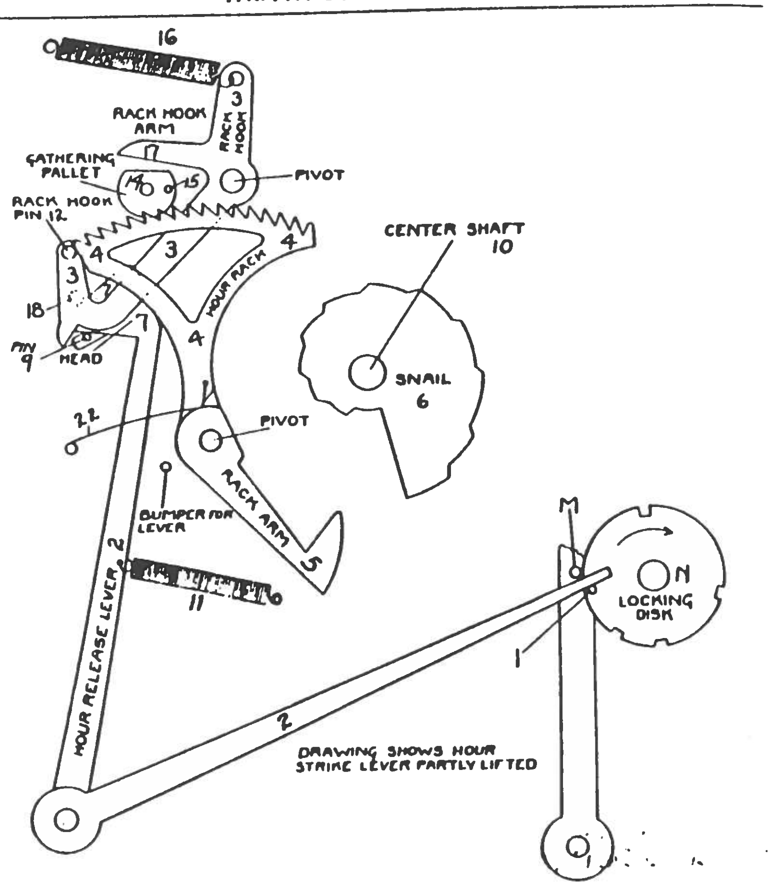
Because of the angle on which the gear arm gear W enters the center wheel care must be used in setting the cylinder 25. If the cylinder is not set correctly and the last chime lever has not dropped off cylinder pin 26 or the first chime hammer of the next quarter begins to rise before the shift arm pin M can drop into the slot on the locking disc N, the chime will continue to operate, as there must be no load on cylinder or chime train of gears when pin M is ready to enter slot in locking disc N to let gear W come out of mesh with center wheel Y.

To set the cylinder, remove locking disc N from its shaft which will permit the cylinder and chime train to turn freely. The cylinder 25 should then be advanced until pin 26 which is marked with an arrow, is about ⅛" away from chime lever 27. The locking disc N should then be replaced having pin M on shifting arm K in slot O (the first quarter chime slot) and to the upper side. Then fasten locking disc tight on this shaft by its set screw.

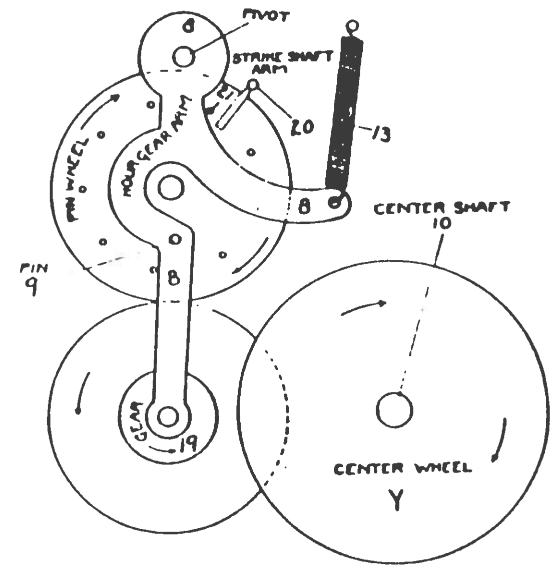
Hour Control

(Left Side of Movement)

As the locking disc N revolves and starts on the fourth quarter chime, pin 1 raises the hour release lever 2, whose



head 7 raises rack hook 3, by engaging pin 18, permitting the rack 4 to fall the correct number of teeth and the rack arm 5 to take its position on the snail 6, corresponding to the correct hour. (Note: Dial wheels which are behind hour snail should be reassembled according to marks on them so hour snail will be in correct position.) The hour release lever head 7 holds the hour gear arm 8 out of mesh by sliding over pin 9 when the rack hook starts to leave pin 9. As the chime is ended the hour release lever 2 drops off the pin 1 in the locking disc N and permits the rack hook pin 12 to fall in the teeth of the rack 4. The hour release lever 2 is moved back to its original position by spring 11 and the hour gear arm 8 is released and the small gear 19 is pulled into mesh with center



THESE PARTS ARE DIRECTLY BEHIND FRONT PLATE AND BY NOTING PIN 9 AND CENTER SHAFT 10 ON BOTH DRAWINGS, THE POSITION OF THESE PARTS IN RELATION TO EACH OTHER CAN BE UNDERSTOOD

wheel Y by the coiled spring 13 attached to arm 8 and the strike begins. This spring 13 should be just strong enough to pull the gear 19 safely into mesh. The gathering pallet 14 begins to turn and makes one revolution every time the hour strikes once and its pin 15 gathers one tooth every revolution. As each tooth on the rack 4 is gathered the rack hook pin 12 drops behind it and prevents the rack from returning to its original position. After all the teeth have been gathered the rack hook 3 drops to its original position, striking hour gear arm pin 9, disengaging the hour gear arm wheel 19 from the center wheel. The spring 16 on the rack hook 3 should be strong enough to overcome the spring 13 on the gear arm 8 and disengage gear 19 from the center wheel Y. If the hour gear arm spring 13 is stronger than rack hook spring 16 it will be impossible for the rack hook 3 to push the gear 19 out of mesh and the strike will continue to operate.

The rack hook pin 12 should rest in the bottom of the rack teeth when rack arm 5 is properly set to engage a step on snail 6. Adjust this when minute hand is at 12 by slightly moving rack arm 5, being careful not to loosen friction. The gathering pallet pin 15 should engage each tooth fully and toward the bottom of the tooth and gather just enough so the rack hook pin 12 safely moves over one tooth but not over two teeth. (If pin 15 hits top of tooth the movement will bind and stop.) Adjust this by slightly bending pallet pin 15 forward or backward. Both of above adjustments should be tried at 1, 3, 6, 9, 12 o'clock. You will note there are 5 teeth between rack hook pin 12 and gathering pallet pin 15.

The hour gathering pallet 14 when locked should permit the rack hook arm 17 to rest on its flat side so pin 15 is free of rack teeth. When pallet 14 is properly locked the strike shaft arm 20 should be about 1/32" away or in front of the pin 21 on the pin wheel, which is to lift it next. If shaft arm 20 is not set correctly, the pallet 14 should be pulled off of its shaft and reset. In operation, the hammers should fall first and then the pallet should gather. If the pallet does not lock on the flat, the pin 15 should be bent slightly towards the center to give the pallet more time to lock.

If Time Train Stops

1. If time train stops and spring is wound up, the clock may be out of beat. Level the clock until the beat or tick is even.

2. If time train stops and the main spring is wound up, as per lines 23 to 27, lifting lever spring L may be so strong that the main spring will not have enough power to operate the lifting lever F thru pins A, B, C and D on lifting disc E which is fastened to the center shaft. This can be overcome by weakening spring L.

3. If time train stops, having had current on constantly, and spring is run down, the clock is not winding. If slotted shaft on back plate can be given 4½ or 5 turns, you know the equalizing mechanisms are not working properly and the clock is run down. To make clock wind correctly, turn eccentric 60 about 1/16" to the right as you face the back of the movement. See lines 16 to 48.

If Clock Fails to Chime

1. Lifting lever F may not throw over far enough to let shifting lever hook H drop behind pin J in shifting arm K.

Bend lifting lever F slightly to the left at the end where it comes in contact with the lifting pins. Each pin should be tested. See lines 49 to 62.

2. Lifting lever spring L may be broken or too weak and will not pull gear arm gear W into mesh. The lifting lever spring L should be strong enough to overcome the spring X on the gear arm V. Cut one or two coils to make spring L stronger.

3. Chime gathering pallet pin S may not be set correctly. Pin should be at bottom with slack taken up when pin M is in one of the slots in locking disk N.

4. Cylinder drive gear on rear of movement may be loose on its shaft and the cylinder won't turn. Tighten cylinder drive gear by the set screw in the bushing, and reset cylinder. See "Setting Cylinder" lines 118 to 134.

5. The meshing of the chime gear arm gear W with center wheel Y should be about 3/4 of the tooth so they will not bind. This is controlled by the slotted eccentric behind shifting arm K.

If Clock Continues to Chime

1. Cylinder may not be set correctly. See "Setting Cylinder" lines 118 to 134.

2. Gear arm spring X may be too weak and will not pull it out of mesh. Strengthen spring X by turning eccentric slightly to the left.

3. Gathering pallet S may be loose on shaft and won't release shifting lever hook H after slack is taken up, reset with pin to bottom and tighten pallet by driving it on its shaft.

If Motor Stops on Chime

1. Lifting lever spring L may not be strong enough to overcome gear arm spring X to pull pin M completely out of its slot in the locking disc N. The teeth may be slightly in mesh and the disc N will turn, locking the pin M against the slot in disc N. Tighten lever spring L by cutting off a coil or two.

If Clock Fails to Strike

1. The meshing of the hour gear arm gear 19 with center wheel Y should be about 3/4 of the tooth, so they will

not bind. This is controlled by the slotted eccentric behind hour release lever head 7.

2. Gear arm spring 13 may not be strong enough to pull gear arm gear 19 into mesh with center wheel Y. Strengthen spring by turning eccentric slightly to the left.

3. Hour release lever spring 11 may be too weak to return lever to its original position. Strengthen spring by cutting off a coil or two.

4. Hour release lever 2 may fail to raise rack hook 3 high enough to let rack 4 fall. Correct this by bending hour release lever 2 at point it contacts pin 1.

5. Rack may fail to drop. (a) The hour gathering pallet pin 15 may not be set correctly, resting in teeth keeping rack from dropping. Reset hour gathering pallet 14. See lines 178 to 187. (b) Strike shaft pin 20 may be resting on pin 21 which load backs up gathering pallet pin 15 into rack teeth when rack is ready to fall. Reset as per lines 178 to 187. (c) The rack spring 22 may be broken or too weak to make rack fall into position. Strengthen spring.

If Clock Continues to Strike

1. Hour rack hook spring 16 may be too weak to disengage the gear arm gear 19 from the center wheel Y. Strengthen spring 16. See lines 160 to 165.

2. Hour gathering pallet may be loose on its shaft and won't gather the rack teeth. Reset see lines 178 to 187.

If Motor Stops on Strike

1. Hour rack 4 may not be set correctly and gathering pallet pin 15 may be hitting on top of the teeth. Reset hour rack lines 166 to 177.

If the hour gathering pallet 14 continues jumping when hour should strike it is due to spring 13 not being strong enough to hold gears 19 and Y in mesh. Strengthen spring 13 by turning eccentric slightly to the left so it will safely pull gears 19 and Y into mesh. There also may be a bind between the two gears on the gear arms. Bend the arm slightly towards the front plate to give more play between the gears.

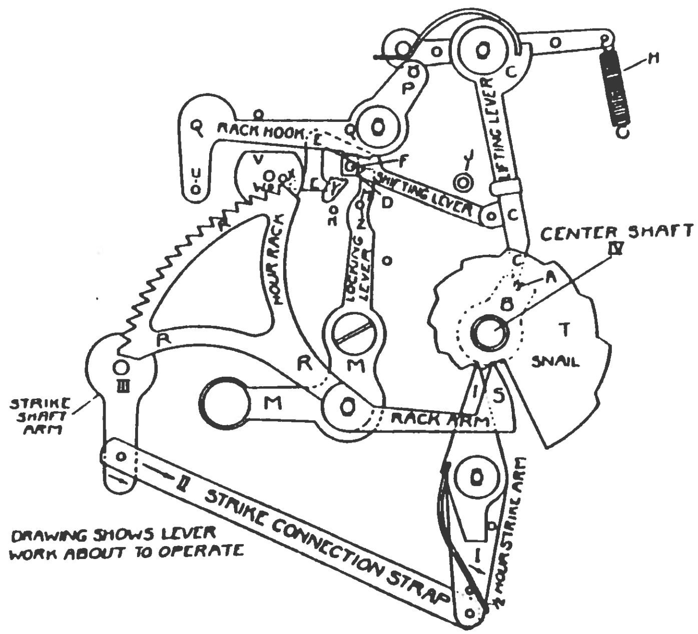
Due to rough handling in shipment the movement may shift slightly and the center arbor touch the side of hole in dial. This should be observed and if arbor touches hole use a good sized screw driver to shift movement to correct position.

Explanation of Hour Strike Movement

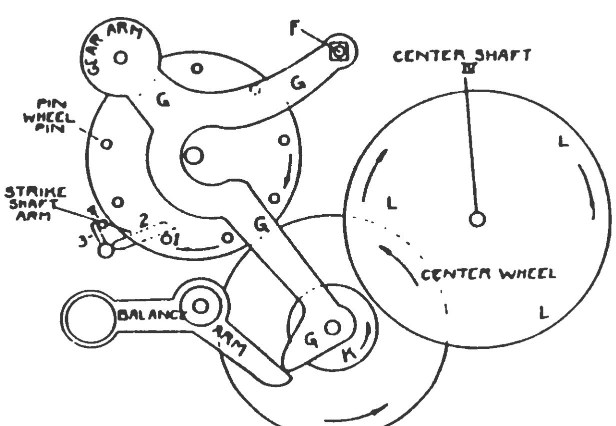
The hour strike is controlled by lifting pin A on lifting arm B which makes one revolution per hour. Pin A lifts lifting lever C to the right, permitting hook D on shifting lever E to drop behind pin F on the gear arm G. There should be a play of about 1/32" or more between hook D and pin F when pin A lifts lifting lever C to its highest point to be sure that hook D drops behind pin F.

When lifting lever C is released from pin A, spring H tends to pull it back to its original position against banking pin J. Spring H should be strong enough to lift gear arm gear K safely into mesh with center wheel L but must not be so strong that the main spring will not have enough power to operate the lifting lever F through the pin A on the lifting arm B which is fastened to the center shaft IV. At this moment hook D pushes against gear arm pin F which lifts gear arm gear K into mesh with center wheel L. The depthing between gear arm gear K and center wheel L should be about 2/3 the distance from the top to the bottom of the teeth. This is controlled by the eccentric which is found about half-way down the plate and to the left of the locking lever. Through this eccentric and to the inside of the plate is a pin which the gear arm G butts against. The depthing of gear arm gear K with center wheel L is controlled by the position of this pin. The balance arm counteracts some of the weight of the gear arm G and should always be free. As gear arm gear K goes into mesh with center wheel L, the gear arm pin F, which has a square shoulder and a round end, is lifted by the hook D on shifting lever E and locking lever M is permitted to drop against its banking pin N and the square end of locking lever M lodges under the square shoulder of gear arm pin F and holds gear arm gear K into mesh with center wheel L until the end of the strike. As long as locking lever M is under square shoulder of pin F, gear arm gear K cannot come out of mesh with center wheel L.

At the same time that lifting pin A lifts lifting lever C to the right to set the strike mechanisms in operation its arm O bears down on pin P in rack hook Q causing rack hook Q to rise and release rack R so that the point of rack arm S falls on one of the steps on snail T which designates the hour to be struck. When pin A lifts lifting lever C to its highest point, rack hook pin U should have a clearance of about 1/4" over the teeth on rack R. There are twelve steps on the snail T, the highest one represents one o'clock and the



DRAWING SHOWS LEVER WORK ABOUT TO OPERATE



THESE PARTS ARE DIRECTLY BEHIND FRONT PLATE AND BY NOTING PIN F AND CENTER SHAFT IV ON BOTH DRAWING, THE POSITION OF THESE PARTS IN RELATION TO EACH OTHER CAN BE UNDERSTOOD

lowest one twelve o'clock. It is arranged so that when lifting lever C is released from pin A and rack arm S is on the lowest or twelve o'clock step, the rack hook pin U will fall in the twelfth tooth of rack R or so that when rack arm S falls on the highest or one o'clock step that the rack hook pin U will fall in the first tooth of rack R and so on for each of the other steps.

As the gear arm gear K goes into mesh with center wheel L which is constantly turning at one R.P.M., the gathering pallet V starts to revolve and makes one revolution each time one of the pins on the pin wheel lifts the strike shaft pin 2 which in turn lifts the hammer and then permits it to fall and hit the gong. As the pallet turns its pin W which is on the back of the pallet raises shifting lever E and releases hook D from gear arm pin F so that lifting lever C can fall against its banking stud J. When lifting lever C is against its banking stud J, the flat part of shifting lever E just behind the hook D should rest on pin F. Then the gathering pallet pin X which is on the front of the pallet gathers one tooth of rack R at a time. The pull of this pallet pin X is just enough to permit pin U on rack hook Q to drop in front of the tooth to the left of it and to hold it there until pallet pin X makes another revolution and takes the next tooth on the rack R. This continues until the rack hook Q drops off the last tooth on the rack R. As the rack hook Q drops off of the last tooth on rack R, its finger Y drops against pin Z on locking lever M and kicks locking lever M out from under the square shoulder of pin F and the gear arm gear K is permitted to drop out of mesh with center wheel L. The rack hook finger Y should almost touch the pin Z on locking lever M when the locking lever is under the square shoulder of pin F and rack hook pin U is in the teeth of rack R. Then the finger Y will be sure to cover enough distance when the rack hook Q drops off the last tooth in rack R, to throw locking lever M completely out from under the square shoulder of pin F. The rack hook Q then rests on the flat side of gathering pallet V. Pin X is placed so as to permit this. The pin wheel should be set so that when rack hook Q rests on the flat of gathering pallet V, the pin wheel pin 1 which will next raise the strike shaft pin 2 is about 1/32" away from the strike shaft pin 2.

The half hour strike is operated by the lifting pin A coming in contact with the pointed end of the half hour strike lever I which pivots in the center. To the half hour strike lever I is attached the strike connection strap II which in turn is attached at the other end to the strike shaft arm III. The strike shaft arm III is fastened to the strike shaft by means of a set screw. When lever I is lifted to the left by lift pin A, it pulls strap II towards the right. Strap II in turn pulls arm III also to the right. This action turns the strike shaft to which the strike hammer is attached. This raises the hammer and when lever I is released from pin A, the hammer is permitted to drop and strike the gong. Pin A releases lever I when the hour hand is pointing directly to the half hour.

If Time Train Stops

1. If time train stops and spring is wound up, the clock may be out of beat. Level the clock until the beat or tick is even.

2. If time train stops and the main spring is wound up, as per lines 23 to 27, lifting lever spring H may be so strong that the main spring will not have enough power to operate the lifting lever C through pin A on lifting arm B which is fastened to the center shaft. This can be overcome by weakening spring H.

3. If time train stops, having had current on constantly, and spring is run down, the clock is not winding. If slotted shaft on back plate can be given 4½ or 5 turns, you know the equalizing mechanisms are not working properly and the clock is run down. To make clock wind correctly, turn eccentric 60 about 1/16" to the left as you face the back of the movement. See lines 16 to 48.

If Clock Fails to Strike

1. Lifting lever spring H may not be strong enough to throw gear arm gear K into mesh with center wheel L. Strengthen spring H by cutting off a coil or two and replacing it on its stud. See lines 287 to 295.

2. Locking lever M may be stuck and will not fall under square shoulder of pin F. This lever should always be free. See lines 304 to 312.

3. If the pin wheel is not set correctly and pin wheel pin 1 lifts the strike shaft arm 2 and prevents the strike shaft banking pin 3 from resting on the rubber coated banking stud 4, the weight of the hammers on the pin wheel will tend

to turn the train of gears backwards when the rack hook Q is on the flat side of gathering pallet V. When the rack hook Q is lifted so that the rack R can drop, the weight of the hammers will turn the pallet V backwards and the pin X will catch in the rack teeth and prevent it from dropping. Pin wheel should be set so that when rack hook Q is on the flat side of pallet V, pin wheel pin 1 should be about 1 32" away from the strike shaft arm 2.

4. If rack does not drop, the clock will not strike. See that rack is always free.

If Clock Continues to Strike

1. Finger Y on rack hook Q may not be set close enough to pin Z on locking lever M and will not kick locking lever from under square shoulder of pin F. Adjust this by bending finger Y at point where it contacts pin Z. See lines 346 to 357.

2. Pin X on pallet V may not have enough throw to completely pull the last rack tooth out from under rack hook pin U. Bend pin W towards the outside of the pallet V until it has enough pull to complete this action. If pallet pin X has too great a throw and pulls the last tooth out from under rack hook pin U before the flat on pallet V is in position to take rack hook Q, rack hook Q will rest on the circumference of pallet V and finger Y will not kick locking lever M from under pin F. Bend pin X towards the center of pallet to overcome this.

If Clock Stops on Strike

The hour rack may not be set correctly and pin X in pallet V may be binding on top of tooth in rack R. Reset rack R as per chime instructions lines 166 to 177.

Pendulum Mantel Chime Clock

Setting-Up Directions

Remove pendulum ball from bottom of case.

Release chime bars by turning metal holder or removing wood block on inside of back of case.

Release chime hammers by cutting string and removing wood block being careful not to bend hammer levers.

Bottom of hammers should be 1/8" from top of bars and should strike the center of bar.

These Herschede electrics will run only on 110 Volt 60 Cycle (or cycle marked on motor) Alternating Current circuit and should be connected to a circuit which is constantly alive. Make sure that there is no switch which is likely to be opened so as to deprive it of current.

Always keep pendulum rod fastened in clip to prevent spring running down when not in use. Pendulum ball should always be attached when movement is operating. Time will run 24 hours with current off. In order to keep the clock wound to its full spring capacity so that it will run through a 24 hour interruption, it should have current on constantly. Notice—Slot in main shaft in back of movement which can be given three complete turns in case movement has run down. Hour Strike will not operate unless current is on.

Setting the hands is very much simplified because of the self-adjusting chime feature which automatically corrects the sequence of the chimes within one hour. There are various ways of setting the hands but probably the easiest is to turn the minute hand backwards to about an hour before the correct time and then forward, letting the clock chime at each quarter. When the chime is in the operation of self-adjusting it sometimes does not chime.

On the hour strike clocks, the hands should be set by turning the minute hand backward to the hour desired. The hour hand should point to the hour struck.

Start pendulum in motion by gently lifting one end of the case. (To insure correct time clock must be in beat.) Regulate clock by using key on the small arbor at top of dial. One complete turn of the key is equal to 3 minutes in 24 hours—turning toward "F" makes movement faster and towards "S" makes it slower.

This clock has been thoroughly tested and run for fourteen days and if, through rough handling in shipment the rack-work should become disarranged it may be necessary to make some minor adjustments on the front of the movement. Our Quick Removable Bezel makes this only a few minutes work by taking off the hands and unscrewing the two fastening screws at back of case. Movement need not be taken from case. If clock has two chimes, either, Westminster or Canterbury Chimes can be used by inserting small key on the square shaft in front of dial and turning slightly in direction marked. This key is attached to inside of back door.

Jeweled Lever Escapement Movement

Special attention is called to the wide range of regulation that can be had on our Lever clock which has a double regulating arm. If enough adjustment cannot be had with the long arm, you can move the short arm which holds the two hair spring guide pins, in the same direction as the long arm was moved.

Floor Chime Clock

Setting-Up Directions

Unpacking the Case

The greatest care should be taken in removing the Clock Case from the packing box. First, the nails that hold the braces in place should be carefully removed before attempting to release them from their fastening. Damage to the Case is chiefly due to careless removing of the braces. Keys for doors are wrapped in package tacked on center brace. Look carefully for case ornaments.

Hanging Tubular Bells

Be careful to keep tubes in sets as they are packed. Each set is tuned in harmony to a predetermined pitch and may vary, even if only slightly, if mixed with other sets packed in the same box. If sets should accidentally get mixed together place them in sets according to small numbers stamped on top of tubes. To hang the bells remove the top of case to gain access to the tube rack. Under no condition remove the back of case. It is not necessary. Hang the bells on the racks provided for them, beginning with the shortest bell at the right and ending with the longest one at the left of the rack as you face the clock. The bell marked (hour strike) on the 9-tube movements hangs on the rack provided for it to the right of chime rack and on the 5 or 7-tube movements it hangs on the left of the chime tubes. Stretch the cord well over the two (2) round head pins, and in such a manner that the knot comes above the center of the bell. Each bell should then be directly behind a hammer. The cord should not touch the bells except at the points where it passes through. Each bell should hang perfectly perpendicular to avoid striking each other when vibrating while chiming. This can be done by pulling the knot one way or the other.

Level Clock

The Clock should stand plumb on the floor and should be perfectly level in both directions, from left to right and from front to back. Use a large spirit level to prove it.

Testing the Chimes

The Clock is now in position to test the Chimes. After turning on the current move the minute hand forward till it

passes the next quarter and it will begin to chime. If any of the bells produce a tone too loud or too weak, adjust the hammer springs either closer to the bell, which produces a louder tone, or away from the bell, which will weaken the tone. Use our patented adjusting thumb nut, which greatly simplifies the adjustment of the springs. *Do not adjust the springs too tight as the hammer will produce a thud when striking the tube.* Be sure the hammers are 1/8" from the tubes. If a louder tone is wanted the leather tips of hammers can be hardened by rubbing a smooth piece of wood or metal over leather using pressure.

Hanging the Pendulum

The pendulum is marked with Case number. After the Chimes are adjusted to suit, hang the pendulum in position. The pivots of the cross bar in which the pendulum spring is fastened should set firmly in the slots provided for them in the suspension bridge on the back plate. The pin attached to the brass disc should occupy the slot in the brass fork. Swing the pendulum from right to left, and if it is not "in beat" loosen the knurled set screw in the brass disc and move the disc to the right or left as may be required, to obtain an even beat. Then fasten the set screw firm. The Clock must be in perfect beat to obtain the best time-keeping result. Each clock is well regulated before leaving our hands. The pendulum rod has a scratch mark on the back indicating the point about where the top of the pendulum ball should be placed. After shipment clock should be re-regulated in position by screwing the pendulum nut to right (up) for faster and reverse for slower. Three (3) complete turns of the nut effects a loss or gain of about one minute in 24 hours. After adjusting or hanging the pendulum on the clock, be sure that the pendulum ball rests on pendulum nut.

Setting Hands

Because of the self-adjusting chime feature which automatically corrects the sequence of the chimes within an hour there are various ways of setting the hands. Probably the easiest is to turn the minute hand backward to about an hour before the correct time and then forward, letting the clock chime at each quarter. The hour hand should point to the hour struck. Note—When the chime is in the operation of self-adjusting it sometimes does not chime.

Setting the Moon

Be sure the moon spring and shift lever are not wedged between the face of the moon disc and dial. The figures and lines on the moon arch do not indicate a calendar month, but do indicate a lunar or moon month, which has 29½ days. Should the moon phase not correspond with the correct age, which may be obtained by consulting an almanac or calendar, then revolve the moon disc, which is done by a slight pressure of the finger on the disc, turning to the right, and proceed until an imaginary line drawn through the center of the moon phase comes in the right position with the arch. For example, if the moon is 12 days old and the arch indicates it 20 days old, revolve the disc until the imaginary line comes in line with 12 on the arch. When the moon is once set correctly it will remain so if the clock is kept running continuously.

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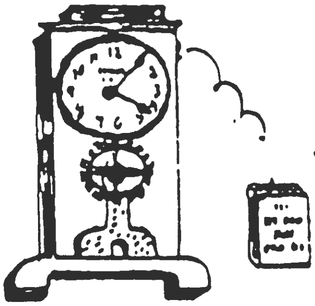


The JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY Chapter No 78

NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

VOLUME XVII, #3, OCTOBER 1991

Fellow Horologists:

This issue, the 3rd of 1991 contains a group of technical articles guaranteed to be among the most interesting, informative and enlightening that we've published in recent months...

The material covering the RUDD Free Pendulum concept originally appeared in HOROLOGY magazine, August 1937. The historical background provides an interesting insight into precision timekeeping and includes a complimentary tribute by Frank Hope-Jones, not normally given over to kind remarks as regards attempts at accurate timekeeping efforts by the horological fraternity.

The article by Alfred E. Ball, reproduced from the Journal of the Royal Society of Arts, September 17, 1909, is especially interesting in the description of the Turret Clock drive, in which the power to the hands is made variable, and is controlled by the load placed on the hands and the power required!

Additionally, Tap & Drill sizes for Metric and British "BS" standards are charted along with French & DIN information... especially handy when working with the construction articles by Wilding and others who refer to foreign thread sizes in their material.

The PORTESCAP/SECTICON material, published in 1965/1966 describes a pre-quartz movement with equal to, or better than quartz accuracy! The article provides comprehensive data covering the rotary motor with transistor control, its adjustments, and srvicing information.

Patent details on the GERRY Self-Winding clock are included, as well as some additional material about the DRAWBAUGH clock; patent information recently published in our journal.

Thanks due to Dr. Feinstein, co-editor, for his re-typing and preparation of the Rudd and Ball material. Good reading ahead...

Martin Swetsky, FNAWCC, President
Harvey Schmidt } Co-Editors
Dr. George Feinstein } Co-Editors

THE RUDD FREE PENDULM

By A. A. Rudd

HOROLOGY HAVING GIVEN an account of the Shortt Free Pendulum, it is meet that it should perform a similar service for its progenitor, the Rudd Free Pendulum, the pioneer work of Robert James Rudd, of Croydon, England. An amateur in the science of horology, Rudd was born in 1844 of a long line of farmers and land-owners in East Norfolk. His grandfather and great-grandfather both kept packs of hounds at Rockland and Bramerton, and in "Records of the Rudd Family" it is recorded that the latter could walk five miles in a direct line without quitting his own property.

Rudd was educated at Hurstpierpoint College, and apprenticed to Maudsley Sons & Field, the then famous Thameside engineers. In 1872, after a European tour with Mr. Henry Maudsley, he entered the firm of Gillet and Bland of Croydon, turret clock makers and bell founders, where he designed, among many others, the turret clock at St. James's Palace (1882), and the handsome bracket clock at the Royal Courts of Justice (1883). Twenty years later he retired in order to devote himself to research and invention.

Among his inventions, many patented, were a machine for the automatic tuning of bells, an electric synchronizer, and lastly the now famous mechanical Free Pendulum in which his genius reached the height of its fullest expression. Invented in 1898, it was gradually developed between 1908 and 1921 by Mr. W. H. Shortt, in collaboration with Mr. F. Hope-Jones, into the Shortt Free Pendulum, first installed at Edinburgh in 1921, and then at Greenwich Royal Observatory in 1924. At the age of 85, in failing health but still working, Mr. Rudd retired to his native county, dying at Hemsby on March 2nd, 1932.

In 1583, when Galileo discovered a certain property inherent in a pendulum, he initiated those searchings after accuracy in the measurement of time which led, in 1656, to the invention of the pendulum itself by Huyghens, followed notably by those of Harrison, Graham and Riefler, and culminating in the Shortt Free Pendulum of today with its progenitor, the Rudd Free Pendulum, now installed side by side in the Science Museum at South Kensington. After Huyghens, perhaps the most famous inventor was Harrison, another amateur, who in 1735 completed a marine timekeeper which measured time accurately enough (with-

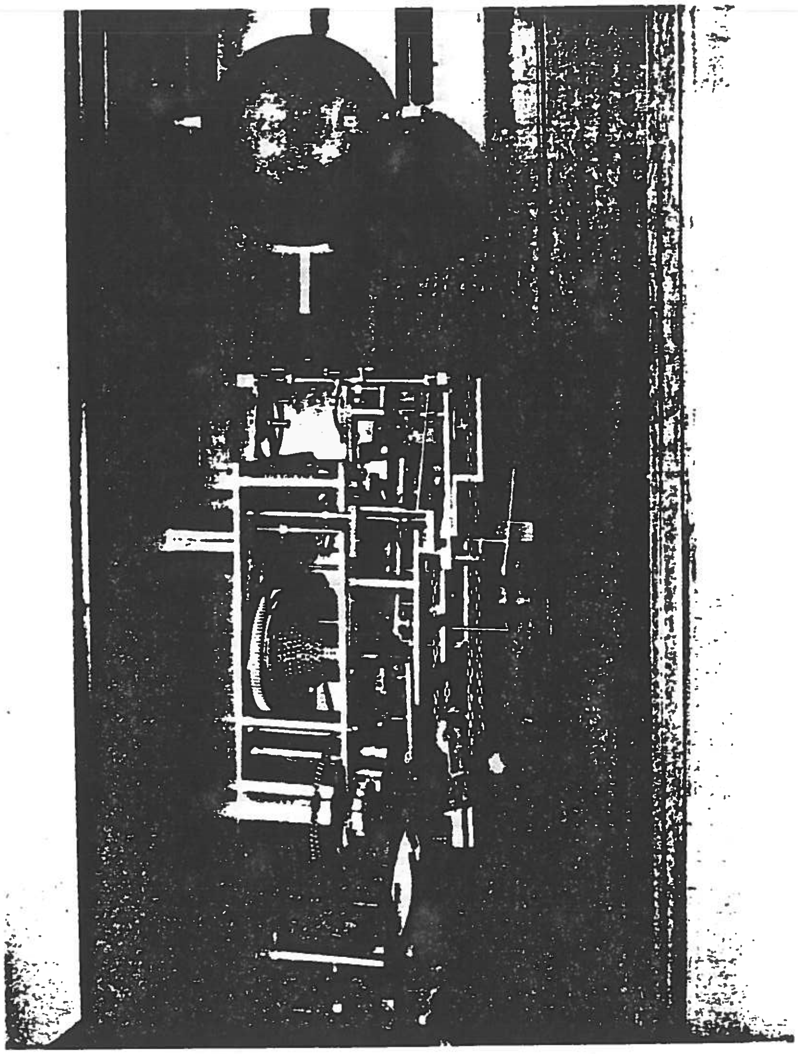
Robert James Rudd
1844-1932

in one second a month) to determine longitude, for which he was awarded 20,000 pounds by the English government. It was during this period that Graham introduced his "dead beat" escapement, more expressively termed by the French, "l'echappement a repos," an invention which was practically the last word in accurate time-keeping for more than 150 years. In the interim many inventions for achieving even greater accuracy were evolved, but Graham held the field until 1890, when Riefler of Munich brought out his detached escapement, a mechanism which was so successful that over 400 were supplied to various observatories between that date and the advent of the Great War.

To revert, however, to Huyghens. In 1656 Huyghens seized upon Galileo's discovery of isochronism, namely, that every vibration of a pendulum is performed in the same period of time, whether the arc described by the pendulum bob be large or small, to apply that property of the pendulum to the regularity of the rate of movement of a clock train. Now this regularity initiated by the pendulum is subject to constant interference by the escapement, thus rendering the pendulum's natural property, isochronism, nugatory so far as accuracy of timekeeping is concerned. And despite Graham, Riefler, and probably many another, but unnoticed, genius, the problem of the elimination of the escapement's interference remained unsolved until 1898. In that year Rudd conceived the feasibility of a pendulum, oscillating freely and not influenced by any escapement whatever, being maintained in motion by the periodic impulses of a mechanical contrivance, (later known as a "slave" clock), entirely out of contact with the Free Pendulum except at the moment—and the right moment—of impulse. This idea had been exercising the brains of inventors for many years, and doubtless many attempts which never came to light were made to solve the problem. However, four remarkable achievements, all doomed to early extinction, did appear contemporaneously with that of Rudd during the first years of the twentieth century, of which Sir David Gill's Free Pendulum (1904) probably approached most nearly to Rudd's. But, unlike Rudd's No. 1, which was purely mechanical, Gill's pendulum was operated by an electric current, which proved so faulty that after the Admiralty had spent large sums of money on the clock (then installed at the Cape Observatory, of which Sir David Gill was Director) it was abandoned in favor of one by Riefler.

As soon as Mr. Hope-Jones examined Rudd's pendulum at Croydon, he realized that it marked the advent of the long awaited revolution in the measurement of time and possessed of an uncommonly generous cerebral bump of altruism, he hastened to obtain the interest and collaboration of Mr. Shortt. During the next ten years these enthusiasts studied ways and means of perfecting Rudd's methods of solving the problem of an efficient Free Pendulum—or rather putting into practice Rudd's principles—and eventually by the introduction, *inter alia*, of the electrical synchronization of a slave clock, the first Shortt Free Pendulum was constructed by Mr. Shortt himself and was erected in Edinburgh Observatory in 1921. Incidentally it is interesting to note that this clock resembled Rudd's in having its impulse movement placed at the bottom of the bob. In later designs it was raised to 7 inches below the suspension spring, a position it still holds. So at long last we realized the dream of a clo[illegible] freed from the trammels of an escapement, and much more—freed from the other ills that all timekeepers were heir to, with the exception of the elusive circular error, an enigma which since 1924 has been under close investigation by the staff of the Royal Observatory at Greenwich.

Whether Rudd's clock, which is operated by mechanical means only, and is of so delicate construction as to need constant attention, could be so modified as to become capable of general use is of no import. It was the first invention that succeeded in rendering a free pendulum practical instead of theoretical, and in his hands it worked, regulating several clocks in his house. But no one else made one, and the only existing example is Rudd's No. 2, which the writer has seen going at the Science Museum, to which institution it was presented in 1930 by Mr. Hope-Jones, to whom Mr. Rudd, with great diffidence, had previously given it.



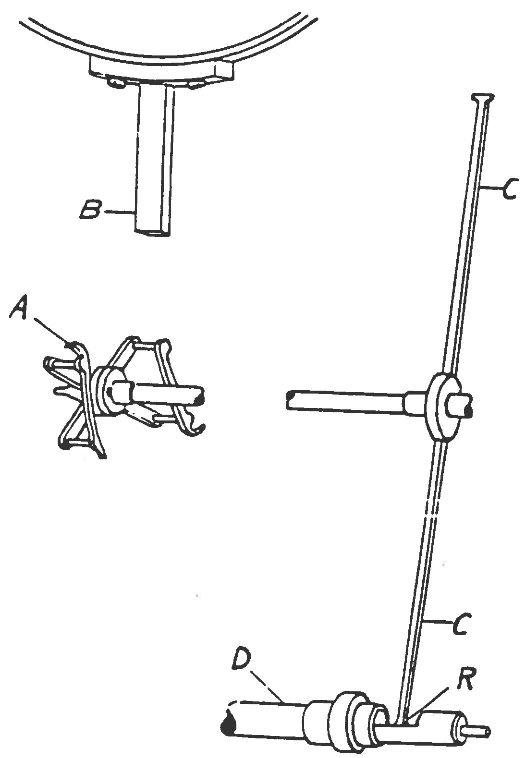
Rudd's Free Pendulum Clock (By courtesy of the Director of the Science Museum, London.)

Rudd's fame, the often unrecognized fame of the pioneer, rests on the fact that he laid the foundation upon which others were to build with success, and that he demonstrated the principles to be followed in order to bring to a practical issue the problem that he had solved. Mr. Hope-Jones, an authority *primus inter pares*, has published his opinion that the result of Rudd's ingenuity is the greatest step toward the goal of absolutely accurate time measurement since the days of Harrison. A generous tribute is due to Mr. Hope-Jones for his efforts in making public the true value of Mr. Rudd's achievement, and especially in bringing to the knowledge of the profession the work of a genius who was only too prone to hide his light under a bushel. In the absence of his energy and enthusiasm, Rudd's work might have lain dormant in the womb of time forever, and possibly that marvellous gift to the science of Horology, the Shortt Free Pendulum, might still have been wanting to the service of astronomy.

Briefly stated, the function of the slave clock is to give an impulse periodically to the Free Pendulum sufficient to maintain it in vibration without interrupting its natural rate of oscillation and without requiring from it any of the energy received by it from the impulse. The function of the Free Pendulum is to regulate (without thereby parting with any of the energy stored within itself through the impulse), the rate of the slave clock until it coincides with that of the Free Pendulum, which latter is, by the law of isochronism, constant.

The accompanying sketch shows a portion of the impulse system, consisting of an arbor carrying a pair of long arms C which impinge consecutively on the grooved arbor D, and are released at intervals of one minute through the cut out recess R in D, at the moment when D makes a half revolution. The arm C, energized by the falling weight on the Huyghens chain, thereupon makes a half revolution, (its opposite member coming into position in its turn against D, where it is locked), carrying with it one of the impulse arms A which gives to the end of the bob B, at or near the zero point, an impulse gently but sufficient to maintain the Free Pendulum in oscillation. Should the slave clock have at this moment a gaining rate, the impulse arm A will arrive at the Free Pendulum a little early and will be held up for a small fraction of a second against the pendulum, and by means of a movable regulator arm, visible in the photo behind the pendulum suspension spring, and whose movement is governed by an ingenious and intricate piece of mechanism not visible in the photo, the slave clock pendulum will be set "slow," and vice versa. If owing to the slave clock having a losing rate, the impulse arm arrives late, the slave pendulum will be set "fast." The synchronizer is partially shown in the photo at the suspension spring of the pendulum, which is seen to be hung between two pins. These pins are attached to the movable regulator arm, which moves them up or down concomitantly with its own movement, thereby increasing or decreasing the effective length of the pendulum.

At each one minute of operation the primary discrepancy between the unvarying rate of the Free Pendulum and the rate of the slave clock will settle down to a rate synchronous with that of the Free Pendulum, and at that stage the impulse arm A will be giving its impulse to the Free Peudulum at the latter's most propitious position; viz.—at zero point.



Sketch showing how impulse is transmitted to pendulum (see text).

ELECTRIC TURRET CLOCKS--NEW "WAITING-TRAIN" TYPE
by Alfred E. Ball
(From "Journal of the Royal Society of Arts"
- September 17, 1909, pgs. 911 - 914)

Several different systems of electrically-driven clocks have been designed and are in use in which the hands are sheltered from the wind; but it appears that no electrical system for driving the exposed hands of large turret clocks exists which is capable of dealing with all atmospheric conditions.

It must be understood that turret clocks with exposed hands are compelled to work under conditions unfavourable to good time-keeping. At times, during a gale of wind, for instance, or a snow-storm, the hands (and consequently the clock) are helped forward, and at other times they are retarded, so much so that time-keeping is interfered with, and in fact public clocks are often found to be stopped after a storm.

Horologists have for many years past applied themselves to the problem of separating, if possible, the time-keeping function of the clock from the hand-driving mechanism in order that ever varying pressure of the wind on the exposed hands may not affect the time-keeping of the clock. To this end, various remontoir trains have been invented and a number of gravity escapements. The best-known type of the latter is probably that of the late Lord Grimthorpe, which is largely and in fact almost exclusively used in this country.

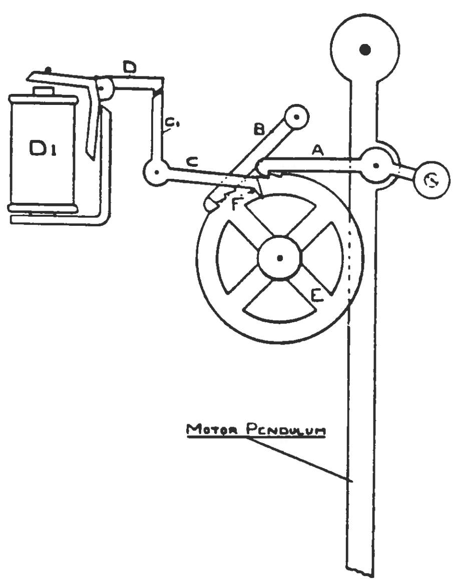
An arrangement which was probably first adopted in England and is now favoured for large clocks in America, is to provide a light, finely-made time-train and impose on it time-keeping duties only, while a heavy powerful train is provided for driving the hands, the progress of the latter being controlled entirely by the former. Such an arrangement is certainly a step in the right direction. A mechanical connection, however, has to be maintained between the two trains of wheels, and consequently the two functions cannot be entirely dissociated.

With an electrical turret system, however, which has been invented by the firm of Gent and Co., Ltd., whose factory is at Leicester, an entire dissociation of the time-keeping and hand-driving functions is obtained.

The electric hand-driving train, instead of being driven by a force of fixed value (such as a weight), as in a mechanical turret clock, which has to serve both when the load is heavy and light, is constructed so that its power becomes automatically adjusted to suit the load, the load in fact determining the power to be developed. The only connection between the hand-driving function and the time-keeping function in this new arrangement is the simple electric connecting wire, which obviously cannot transmit any mechanical resistance that may be applied to the hands.

This "waiting-train" movement consists essentially of a vibrating motor pendulum, and a half-minute time control. The vibrating motor pendulum, when working, becomes re-energised as often as the amplitude of its vibrations fall below a given value. In vibrating, the motor pendulum by means of a hook-shaped pawl, **A** (shown in the accompanying diagram No. 1), pulls around the 'scape wheel E, and the wheel-train gear, tooth by tooth.

FIG. 1.



Normally the re-energisation of this motor pendulum takes place about once per minute. It is obvious, however, that if resistance is applied to the hands, such as is produced by wind pressure, storm, snow, &c., these re-energisations would take place more often, in fact, even as often as at each vibration, if necessary.

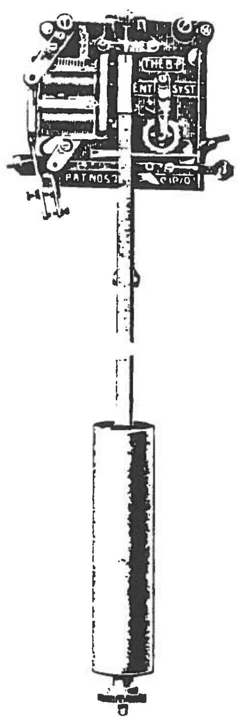
Working under these conditions, the motor pendulum is found, as would be expected, to develop considerable power, even from 40 to 50 times that which is normally required. As all clocks with exposed hands have to deal with a varying load, the condition of driving are completely met by the "waiting-train" movement.

The half-minute control operates as follows:
The simple train is so designed that the motor-pendulum in vibrating advances the hands half-a-minute in approximately 27 seconds. A pin, F, in the escape-wheel, E, then lifts the control-lever, C, and disconnects the pawl, A, of the motor-pendulum from the train of wheels by lifting it out of the wheel, E, and allowing the motor-pendulum to oscillate idly. It is here that the control from the entirely dissociated time-keeping mechanism comes into operation. This time-keeping mechanism (which is described below) is known as the B.P. Patent Time Transmitter, and its duty is to send out electrical impulses precisely at each half-minute.

On the periodical half-minute impulse of the time-transmitter occurring, the control magnet, D1, becomes energised, the control lever, C, is released, and the motor-pendulum again drives forward the hands as before, the control being repeated at each and every half-minute, and in this manner the heavy exposed hands are propelled with practically a continuous motion. It is obvious that, no matter how exposed the turret clock driven by this system may be, its accuracy becomes equal to the accurate time transmitter controlling it.

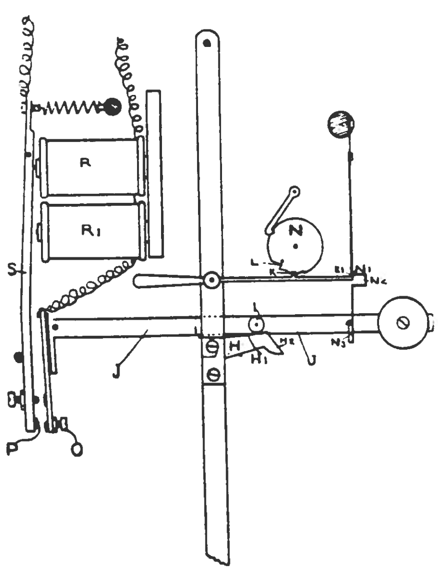
The time transmitter mechanism effecting the half-minute control, and shown in illustration No. 2, is driven on a gravity principle which establishes a new type of escapement or rather propellment, differing widely from gravity escapements hitherto employed. In the older types of gravity escapements, the pendulum is obliged to lift its own driving force at each swing in order to unlock the escapement. It has in fact to perform a recoil action. This work also is imposed on the pendulum at a time when it should be left severely alone, that is to say, at the end of each swing when its kinetic energy is at its lowest ebb, and when the pendulum is in a condition in which it would easily be influenced by varying friction while doing such work.

FIG. 2.



With the B.P. gravity principle the pendulum is entirely free at the end of each swing, and the work of unlocking the gravity lever and also the application of the impulse takes place when the kinetic energy of the pendulum is considerable. The roller and pallet method of gravity impulse allows the gravity lever to be at all times very close to its work, and to be applied at the most advantageous moment.

FIG. 3.

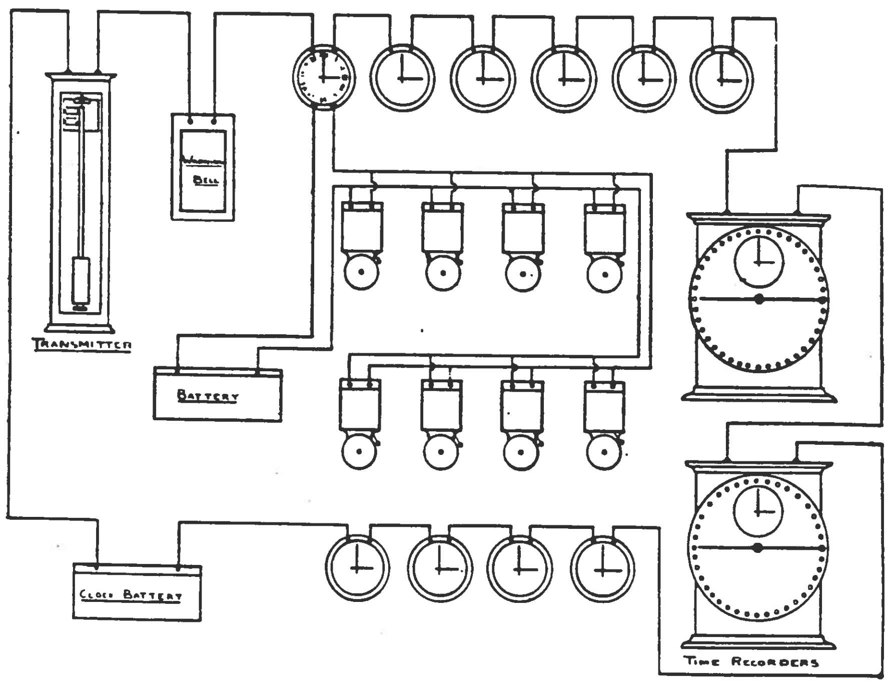


The application of this gravity impulse to the pendulum is effected in the following manner:
Normally, when swinging with the endulum, the pallet, H (shown in iagram No. 3), passes close under but does not touch the roller, I, of the gravity-lever, J. At each half-minute, however, the pawl, K, engages the deeper cut tooth, L, of the scape wheel, N, and enables the pawl extension, K1, to engage the supporting catch, N, at the point, N1 (instead of passing through the stirrup, N2), and so releases the gravity lever, J, from the catch at the point N3. The gravity lever being freed, the roller, I, drops on to the "dead" face, H1, of the pallet, H, and on rolling down the incline, H2, of the latter, imparts to the pendulum the impulse of constant force. This impulse is completed by the gravity lever being definitely arrested by the platinum surface, O, meeting the platinum surface, P. The circuit

being completed through their surfaces, the magnet, R R1, becomes instantly energised, and the gravity lever is lifted to its (original) potential position by the armature, S, the circuit being again broken by the contact-breaking screw, T. The current which flows for an instant through the magnet, R R1, also flows through a circuit or circuits containing impulse clocks, turret clock controls, or other apparatus, such as workmen's check clocks, which it may be desired to operate by the periodical half-minute impulse. Diagram No. 4 shows such a circuit, in which are operated impulse

914 JOURNAL OF THE ROYAL SOCIETY OF ARTS. *September 17, 1909.*

FIG. 4.



clocks, workmen's check clocks, also a number of bells which are automatically rung (by means of contacts within one of the clocks) at the times of starting and stopping of work in factories, &c. The warning bell shown in the diagram is one of the features of the system. This bell gives audible warning when the battery is weakening--long before the battery would fail however--thus preventing a stoppage of the system through a failing battery.

The transmitter, when controlling a turret clock, is usually fixed at the base of the tower or similar low-level position where it can easily be reached for occasional regulation, and this does away with the need of mounting the steps of a tall tower. This low position also gives the advantage that the transmitter is not subject to the vibrations often present in a higher position in the tower. It will be readily recognized that to be able to fix the time-keeping mechanism in the most suitable position for good time-keeping, regardless of the position of the large clock, is an advantage which cannot be overlooked. It will also be recognised that with this electrical system of driving the hands, a large turret clock with exposed hands can be easily made to keep time to a degree of accuracy hitherto only associated with astronomical regulators. Electric striking and chiming can also be added which is entirely automatic in its action, and there is no limit to the size of the bells which may be struck. The whole of the apparatus is worked off Leclanche cells, the current consumption being small, and no winding or attention is required.

A description of this electric time-keeping system would hardly be complete without a short reference to an automatic lighting device, which turns on the gas or electric light (employed to illuminate large public dials) at dusk and turns it off at dawn. The time, however of lighting up may vary from 4.2Ø p.m. in the winter to 1Ø p.m. in the summer, with an equal variation of time for the switching off. Seeing that with electric clocks there is no longer need to ascend the towers for the purpose of winding, it would be a pity to have to do so each week just to reset the times of lighting up and turning off. By an ingeniously-arranged cam, however--which by means of simple reducing gear revolves only once in two years--the times of lighting and extinguishing are altered automatically. The error due to leap years is so nearly allowed for, that the error remaining is only 1Ø minutes in 3Ø years, and at the end of this period can be corrected and reset for a subsequent period of 3Ø years in less than one minute. This device is the invention of I.H. Parsons and A.E. Ball, the patentees of the various clock apparatus described above.

Electrical and Electronic Timepieces and Their Maintenance

(See "Swiss Watch and Jewelry Journal" Nos. 5-6/1965 and 4-6/1966)

by Lothar M. Loske

The movement Portescap

When examining the Portescap movement with which the Secticon clocks are fitted, the watchmaker of today may have the same impression as watchmakers once had when regarding a chronometer or a beautiful repeater watch. The previously described calibers of clock movements have opened the way to new horological techniques. In most cases the old fundamental rules for the construction of mechanical movements are no longer valid. The construction of the Portescap movement has many new and unusual aspects and yet the movement itself is very fine in its execution. Its outstanding execution sets limits to the production in series which is quite unusual in watchmaking.

The range of Secticon clocks **(Fig. 50)** proves that bold forms can fit in with the search for style.

The Portescap movement, because of its quality and particularly its excellent rating results, does not only appear on the market fitted into Secticon clocks but also in chronometers of other makes. Some of the Swiss watch-manufacturers use the Portescap movement in display-window chronometers to show the exact time to passers-by.

Technical information

Size (movement alone)	44 × 44 × 29 mm (customs regulation)
Number of jewels	13 jewels
Protection against shocks	Incabloc ® for the balance wheel and the rotor
Lubrication	Synta-Visco-Lube oil
Escapement	magnetic principle, with detent and constant power device
Oscillations	7200/h
Balance wheel	nickel silver without screws
Hairspring	1st quality Isoval for chronometers; thermo-elastic coefficient of ± 0.2 s/°C/24t
Motor	continuous rotation, with transistor and without contact
Source of power	standard 1.5 V leak proof battery
Annual consumption	2.2 Ah
Life with same battery	15 to 18 months with normal battery size D
Maximum length of hands	without seconds hand: 180 mm (width 6 mm) with seconds hand: 70 mm
Quality	the Portescap movement is produced by the manufacturers of Incabloc ® and Vibrograf ®

Rating results

Test	Results of Observations (seconds)		Limits for Obtaining Certificate with Mention (seconds)
Average daily rate	— 1,9	— 1,5	— 2,0 à 6,0
Average variation	0,66	0,36	1,5
Greatest variation	2,2	1,0	2,5
Difference between 1st and 7th day at 20° C.	2,6	1,4	5,0
Variation per degree C.	+ 0,01	— 0,18	± 0,20
Middle temperature error	+ 0,4	— 0,9	± 3,0
Return to rate	+ 0,2	+ 0,5	± 2,5

In practice these results are not always obtained. Here the position of the movement is very important. For the Portescap movement the best position is the vertical one in which the balance and the escapement are horizontal, and the arbor of the motor vertical. It is not always possible to achieve this position. Whether for every day use or as precious article the watch or clock demands, besides high precision, an elegant, modern design. This twofold purpose (technical and aesthetic) can only be respected by a compromise, of which the Secticon clocks give a good example **(Fig. 51).**

General description (Fig. 52).

The Portescap movement does not resemble any of the previously described mechanical and electrical movements. The entirely new concept of its regulating device, operated with a transistorised motor with a continuous rotation, makes it possible to obtain a precision of ± 2 seconds per day. Three major elements are responsible for this precision:

the detent escapement with its constant power, has an impulse hairspring which is rearmed with the same power at each oscillation, thus guaranteeing impulses to the balance wheel which are always constantly even;

the variations of the motor, namely the gradual running down of the battery will, in no way, have an influence on the accuracy from the escapement, this accuracy will remain constant as was set originally, until the complete exhaustion of the battery;

a specially designed regulator with a micrometric regulating screw, makes it very easy to make corrections up to a fraction of a second; therefore, the maximum precision performance of the movement can be obtained.

The Portescap movement is designed so that normal maintenance can be done without special tools or knowledge. Its three basic units, fixed to each other with simple levers, are interchangeable.

The Portescap movement comes in several adaptations which makes it very practical for use in clocks of different styles; with or without a seconds hand, with or without a central

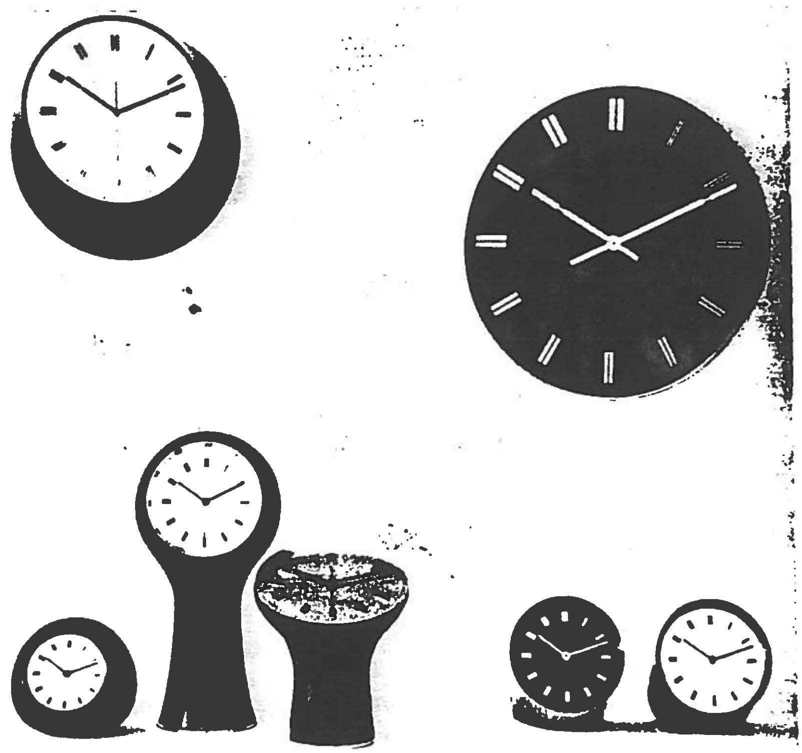


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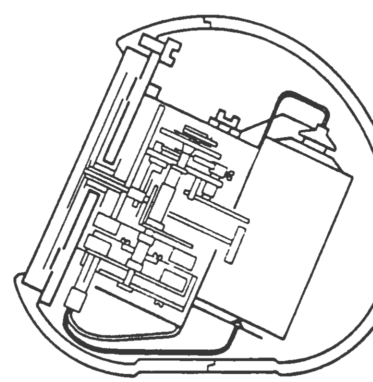
Fig. 50. The Secticon models are differentiated according to their destination: the diameter and incline of the dial are adjusted to the line of vision and to distance. All are equipped with Portescap transistor movement.

Fig. 51. Position of movement in one of the Secticon clocks.

Fig. 52. The Portescap movement.



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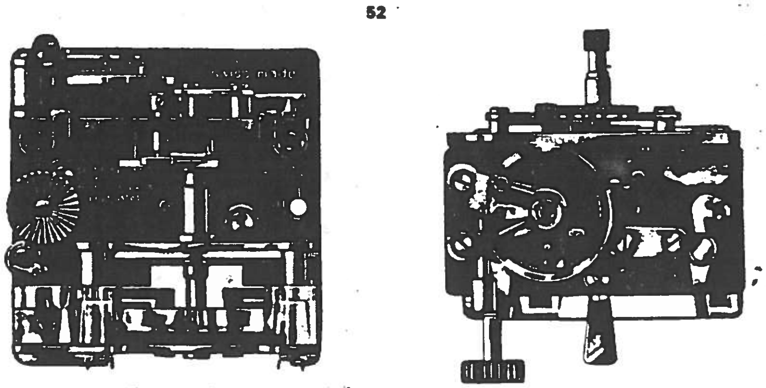


fitting, and with or without an exterior handsetting.

The units.

1. Train wheels (Fig. 53).
This unit is composed of a plate and two bridges holding the seconds, the minute and the hour-wheels, the third-wheel and pinion, and also the hand-setting stem. An adjusting ring holds the minute wheel. The base plate has two supporting pillars with two conical posts used to guide and hold the regulating unit.

2. Motor unit (Fig. 54).
This unit has four elements:

1 a plastic frame with the electric circuits and the transistor, together with the pilot and drive coils

2 a bridge with a tube and bearing for the upper rotor shaft

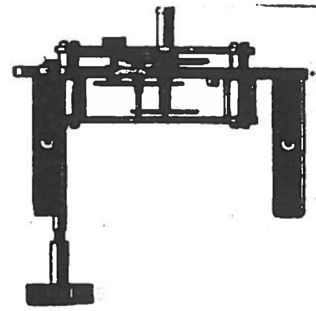
3 a rotor carrying two thin plates which are parallel and similar; each one has at both ends a permanent and polarised magnet of very high quality; a starting pinion (b), an arming pinion (a) geared to the regulating unit **(Fig. 55)**

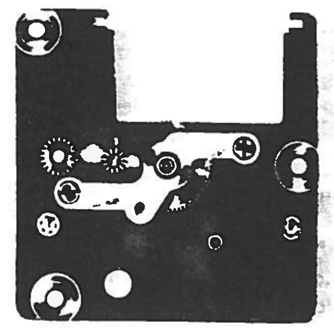
4 a lower plate for the assembling of the unit and with an Incabloc shock-absorber for the lower rotor shaft; this plate also carries the levers holding the motor unit to the base plate.

Functioning of the motor unit.— When the rotor is between the coils, the transistor does not let the current go through. In rotation, the rotor makes one of the pairs of magnets go over and under the pilot coil, inducing a tension which opens the transistor. The current from the battery can then go through the drive coil. In going through the drive coil which, at that time, is in the magnetic field of the opposite pair of magnets, the current creates a rotation force making the rotor turn. The rotation speed can vary from 500 to 1000 revolutions per minute, depending on the voltage of the battery.

3. Regulating unit (Fig. 57).
This unit is a magnetic escapement system with constant power of an entirely new type and consists of the following principal elements:

1 a plastic detent wheel, with three segments, a star with three points, in relation to the segments of the detent wheel and riveted to it; the system is





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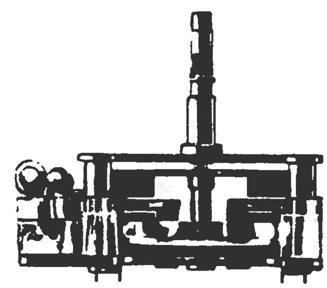

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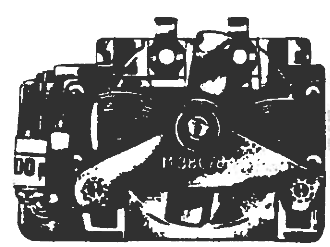

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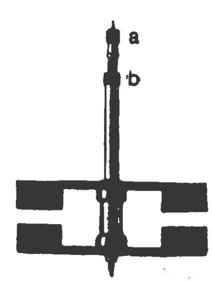


Fig. 53. Train wheels.

Fig. 54. Motor unit.

Fig. 55. Rotor ; a = arming pinion ; b = starting pinion.

fixed to an axle with endless screw and two pivots (**Fig. 58**); the lower pivots in the bearing of the movable bridge and the upper in the bearing of the detent bridge

2 a detent with an edge where a detent spring and a protective blade are riveted; the detent has a stop pallet, a starting pallet, a jeweled pallet, and a magnetic attraction stem; the detent pivots with a staff between the plate and bridge (**Fig. 59**)

3 an impulse spring attached, on one side to a ring which is part of the detent staff, and on the other side to a stud held securely on the plate

4 a permanent magnet held by two small plates; this assembly is mounted on the plate with an eccentric, which permits true orientation (once the setting is made, a tightening screw prevents any shifting)

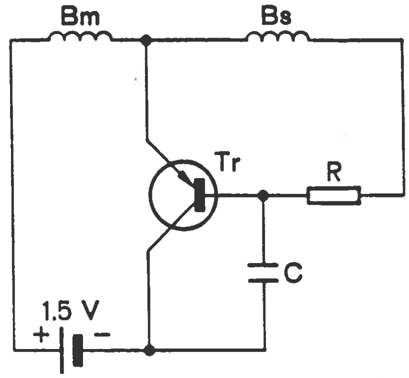
5 a very heavy nickel circular balance wheel attached to a Breguet self-compensating hairspring with a special thermo-elastic coefficient of $\pm$ 0.2 s/°C/ 24 h; the roller with jewel is on staff of the balance wheel; the very fine pivots are protected with an Incabloc shock-absorber

6 a regulator with a special key allows for the setting of the hairspring shake with great facility; the regulator is held only by a friction spring of light pressure; therefore, it turns very freely around the Incabloc shock-absorber; another spring blade attaching the regulator to the micrometric setting screw permits extremely delicate adjustments of fractions of a second per 24 hours

7 a stop lever, riveted to an axle under the plate, bears a starting rack with a return spring geared to the starting pinion of the rotor axle; above the plate, the axle with the stop lever operates a stop spring blade with the help of a collet which puts the detent back in its balanced position and pushes against the roller for the start or for the stop.

The functioning.

When the Portescap movement is stopped, the arming pinion is at the level of the detent wheel, and the endless screw interlocks with the second wheel. The hairspring balance wheel assembly is, in its balanced



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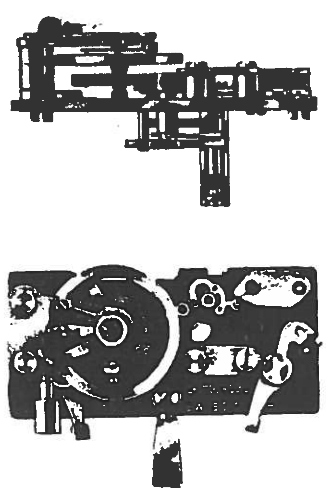

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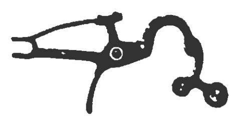

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Fig. 56. Electronic control circuit of motor.

Fig. 57. Regulating unit.

Fig. 58. Detent wheel.

Fig. 59. Detent.

position, entirely free, while the detent is submitted to the tension of the impulse spring.
By moving the starting lever from its rest position, the rack gears with the starting pinion of the rotor. At the same time the stop blade has brought back the detent to its balanced position, that is to say against the reverse block stop, and has armed the impulse spring. The stem of the detent is now in the magnetic field of the permanent magnet which holds it back. This movement of the stop blade has moved the balance from its balanced position, while arming the regulating hairspring.
If the stop lever is released abruptly, it will immediately return to its rest position because of the return spring, and the movement will start. If, on the contrary, a restraining action is applied to the spring, the impulse is not sufficient to start the rotor and it will remain immobile; however it will free the balance wheel which will oscillate somehow, and make the detent return to its first position. The movement therefore does not run.
Figure 60-1.—To make it easier to study the different steps, let us suppose that the balance wheel has been stopped without the use of the stop lever, so that the rotor is still turning. The winding pinion is found in one of the three segments of the detent wheel, because this latter is stopped by an arm of the star against the stop pallet. The detent being in its balanced position, these two movable parts will not interlock, due to the reciprocal position of the winding pinion and the detent wheel.
Figure 60-2.—When the hairspring balance wheel assembly, by its roller jewel, moves the detent, it induces the detent with its detent blade, which presses on the protective blade. This rotation of the detent separates the gravity stem from the permanent magnet until its power is weaker than the torque of the impulse spring, which then acts on the motion of the detent and consequently transmits an impulse to the balance wheel through the roller jewel.
Figures 60-3 and 60-4.—The impulse ended, the motion of the detent continues, while the stop pallet no longer holds back the star, nor the detent wheel to which it is attached. The starting pallet, at the time, pushes the back of one of the arms of the star. The star, in turning with the detent wheel, gears to the winding pinion, inducing through friction the segment of the wheel to the next slot, where it turns continuously. During the rotation of the detent wheel, one of the arms of the star pushes the jewel pallet of detent to bring it back to its balanced position where the permanent magnet will hold it. This rotation assures at the time the rearming of the impulse spring until one of the arms of the star stops the detent wheel by hitting against the stop pallet. During the return motion of the balance wheel, the detent blade will simply bend, without producing any other movement of the escapement.
Each rotation of the detent wheel will push forward the seconds wheel a half second, under the direct but intermittent action of the motor. In the usual watch movement, the motive force is transmitted to the escapement directly by the train, therefore all the factors which influence this motive force will have a repercussion on the running. In the Portescap movement, the motive power gives no impulse to the hair-spring balance wheel assembly; it simply rearms the impulse spring and pushes the hands, independently of the regulating system.
We can see, therefore, that the speed of the rotation of the motor has no influence on the chronometric precision of the movement. As long as the battery has enough energy to give the motor a torque superior to that of the impulse spring and to push the hands, the Portescap movement functions without any changes in the quality of its adjustment. When this torque becomes too weak, the movement stops, and it is time to change the battery.

Immediate service.
The three units of the Portescap movement (train wheels, motor unit and regulating unit) are interchangeable.
The motor unit and the regulating unit are both held by the base plate with two levers. To replace either unit, just

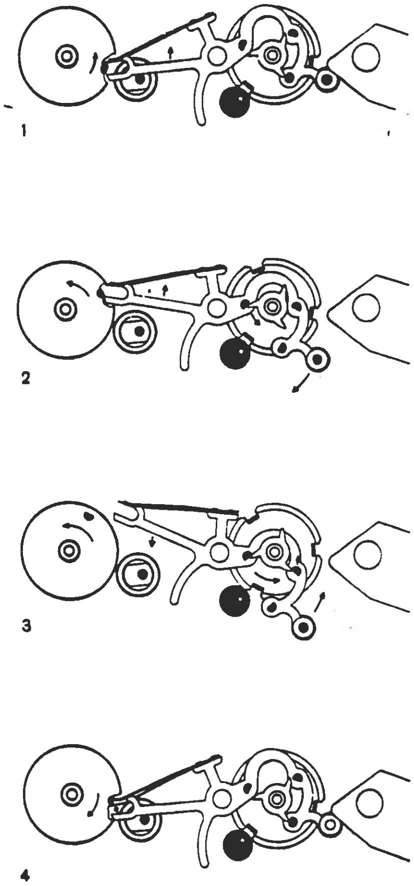


Fig. 60. For better understanding, the impulse spring is not indicated.

release the levers, take any unit out, put in the new unit and reset the levers.

This construction makes the maintenance and the repairs simple, fast and rational. As a matter of fact, the movement can be repaired without any delay ; just replace the damaged unit with a new, or even reconditioned one, either at the factory, or at a qualified repair center.

The actual repair of the damaged unit can be done later in a more economic way and with the best results.

To simplify the shipment of the motor or regulating units, and to guarantee their protection, a special container is available. It is designed to hold either a motor unit, or a regulating unit. The container being made of transparent plexiglas, it is possible to see which unit is inside. A slightly bevelled edge helps in the stacking of several containers.

Controls to be effected after changing the regulating unit.

1 check that the thin wire spring presses well against the movable bridge and make sure of the relative position of the endless screw and of the second wheel; there should be a little play between the endless screw and its tube when the movable bridge is displaced

2 see that the impulse spring is flat and that it touches neither the detent bridge, nor the motor tube

3 with the motor running, make sure the seconds hand is properly set.

Maintenance.

1. Train wheels.

The unit with the train can be disassembled, cleaned and reassembled under usual procedure. Only the minute wheel should not be cleaned, since it works on greased friction.

For oiling, the manufacturers of the Portescap movement recommend the use of Synta-Visco-Lube oil for all pivots, and also for the minute stud.

After pushing back the guard ring of the minute wheel, check the end shake of the minute wheel.

2. Motor unit.

1 unscrew the two assembling screws to separate plate, frame, bridge and rotor

2 clean the Incabloc shock-absorber, using the method recommended by the manufacturers

3 clean the motor tube bearing

4 clean the rotor, making sure that no metal particles stick to the magnets

5 disassemble the winding pinion (this delicate operation should be done only by a watchmaker specially trained and with the proper tools)

6 carefully clean the frame of the electrical assembly; do not use liquids

7 put a drop of Synta-Visco-Lube oil in one of the notches of the oscillating pinion, put pressure to the pinion to make it rotate, in order to spread the oil evenly

8 reassemble the motor without separating or scratching the coil threads

9 oil the pivots with Synta-Visco-Lube oil.

If a defect in the winding pinion, or in the electrical circuits is noticed, it is recommended that the complete unit be sent back to the factory.

3. Regulating unit.

Normally, cleaning and oiling the Incabloc shock-absorber (upper and lower) is sufficient, and there is no need to disassemble anything else.

If a thorough cleaning is necessary, proceed as follows:

1 open the regulator key

2 unscrew the stud screw of the hair-spring

3 remove the balance bridge, then the hairspring balance wheel assembly

4 loosen the impluse spring stud screw

5 remove the bridge, then the detent, and the detent wheel (the permanent magnet should not be unscrewed)

6 wash all parts in benzine (the Incabloc shock-absorber should be cleaned separately)

7 replace the detent wheel, the detent and the bridge controlling the end shake (detent staff 2/100 to 4/100 mm, detent wheel 1/100 to 3/100 mm when the movable bridge is pressed down); the end shake of the detent wheel should be very slight because it is responsible for the movement of the seconds hand; if it goes beyond the tolerance indicated above, the hand will vibrate and not move with precision

8 replace the impulse spring stud and tighten its fitting screw, without altering the strength of the spring (only a specially trained watchmaker can control this)

9 make sure that the detent blade is slightly detached

10 check the functioning of the wire spring of the movable bridge; its very weak tension should be exercised freely—if this tension is too weak, the gear of the endless screw and the seconds wheel will not work properly, and the seconds hand will vibrate; if, on the contrary, this tension is too great, the motor will increase its current consumption, the oil between the endless screw and the seconds wheel will disappear, and the movement could stop

11 the oiling will be done with Synta-Visco-Lube oil for

the jewels of the upper and lower Incabloc shock-absorber

upper and lower detent jewels

upper and lower detent wheel jewels

upper and lower pivots of the movable bridge

the flat of the detent jewel (without the oil touching the detent itself)

behind the arms of the star

the micrometric regulator screw notch

the endless screw (it is advisable to oil the endless screw sufficiently, as the use of the oil, at this point, is relatively high)

12 replace the hairspring balance wheel assembly and the balance wheel bridge, and tighten the hairspring stud screw

13 control the starting and the centering of the hairspring; turn the key leaving as little space as possible, without however impairing the free movement of the hairspring

14 place the movement in its final position and do not move it for at least 36 hours; this stabilization gives

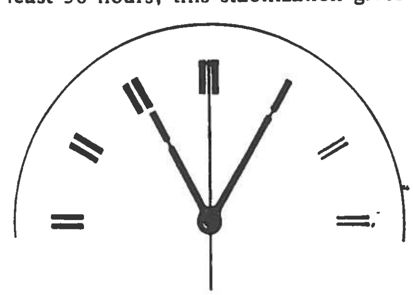


Fig. 61. Put in beat of the seconds hand.

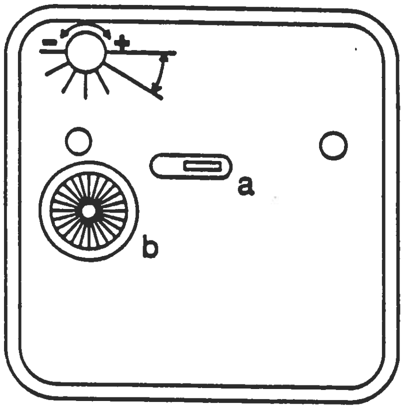


Fig. 62. a = stop lever; b = hand-setting knob.

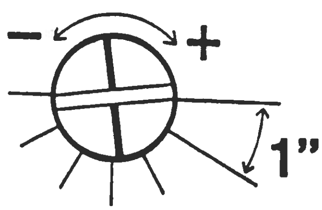


Fig. 63. Micrometric regulating screw.

an opportunity for the oil to spread, the movable parts to reach their definite position, and the hairspring to balance its tensions, conditions indispensable to make any correction of a fraction of a second

15 check again the regulation without moving the movement, by using the Vibrograf (oscillations 7200/h); because of the exceptional conception of the Portescap movement, the instantaneous reading corresponds to the actual running condition.

Time setting.

Once the hour hand and the minute hand are adjusted to each other, and the seconds hand is in place (Fig. 61) proceed as follows for setting the time:

1 stop the seconds hand exactly on 12 o'clock by using the stop lever (Fig. 62-a), then release the lever slowly

2 set the minute hand exactly on one of the dial indexes; the seconds hand will be correct in relation to the minute hand; to turn the minute and the hour hands, press lightly on the handsetting knob (Fig. 62-b) and turn it slowly until it is in gear, then press all the way and turn in the direction wanted

3 start the movement with the stop lever, by releasing it abruptly when the time signal is heard.

Final adjustment.

Once the movement is cased and set in its final position, and after setting the time accurately, place the clock where it will normally be used, and let it run for about ten days.

Then, during the following eleven days, check each day, at the same time, its accuracy. This control will permit to calculate the slight differences which may occur.

The average daily error can be calculated and it will be easy to make the necessary adjustments, using the micrometric regulating screw (Fig. 63). Simply remember that one quarter of a turn of the screw corresponds to a correction of three seconds per day, and that a turn to the right is a gain, and a turn to the left a loss.

CONCERNING THE DRAWBAUGH ELECTRIC CLOCK

Daniel Drawbaugh, of Eberly's Mills, Cumberland County, Pa., was a born inventor. He was that rare, and almost unique type of man with a happy faculty for invention and a most unhappy faculty of making the least of his talents.

The Drawbaugh saga is a pitiful tale, involving as it does a history of developing an electric device for the transmission of speech over wires and the perfecting of the device, years before Alexander Graham Bell displayed his telephone.

This is not just a fanciful story. Drawbaugh did invent and perfect a telephone. Several important companies used his invention. When the showdown came, the Bell interests won by a split decision of the courts.

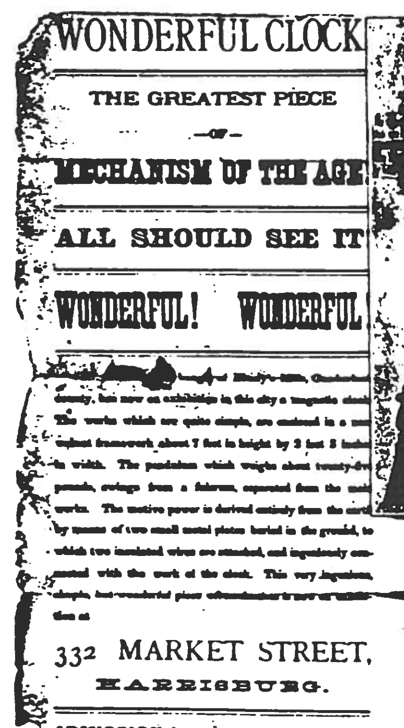
Independent Telephone Companies, which were quite common in many American cities up to c.1910, were the direct outgrowth of the Drawbaugh telephone.

In this matter, we are more concerned with Drawbaugh's Electric Clock which, operating on the magnetic principle, used an "earth" battery which would keep the clock going for years without attention or renewal.

Invented in the 1870s the Drawbaugh Electric Clock is in many respects similar to the Electric Clock of Alexander Bain, fully described in the "Massachusetts Ploughman" June 19, 1847 and commented upon at some length on pages 137-143 of "American Clocks and Clockmakers".

The Drawbaugh clocks were made in three styles of casing; tall case, pedestal type and mural, the latter in the form of a huge banjo, with much carving in the early "Empire" style and only a few disfiguring elements of late Victorian.

In the 1870s and 1880s these clocks were displayed in towns and cities throughout the United States and in Europe. Pictures of the clock and a handbill advertising a display of the clock at Harrisburg, Pa., are shown in this issue of "Timepieces" by courtesy of a direct descendent of the inventor.



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ORIGINAL POSTER advertising the Drawbaugh Electric Clock, 1874, on display at Harrisburg, Pennsylvania, and a newspaper picture of the clock taken from a Harrisburg paper. Very few of these clocks have been preserved in the vicinity of their making but examples may turn up in any part of the country and in unexpected places.

MANHATTAN SUPPLY CO. (Division of Sid Tool Co., Inc.) AMES COURT, ENGINEERS HILL PLAINVIEW, L.I., NEW YORK AREA CODE: 516 433-[illegible]

USEFUL TAP SIZE INFORMATION

Tapping Drills for British Standard Threads

B. S. W.

Nominal diameter of thread	No. of threads per in.	*Drill sizes to B.S. 1157:1944	*Drill sizes to B.S. 1157:1953
in.			
1/8	40	No. 40	2·55 mm.
3/16	24	No. 28	3·7 mm.
1/4	20	No. 9	5·1 mm.
5/16	18	"E"	6·5 mm.
3/8	16	5/16 in.	5/16 in.
7/16	14	23/64 in.	9·25 mm.
1/2	12	13/32 in.	10·5 mm.
9/16	12	15/32 in.	12·1 mm.
5/8	11	17/32 in.	13·5 mm.
11/16	11	19/32 in.	
3/4	10	41/64 in.	41/64 in.
7/8	9	3/4 in.	19·25 mm.
1	8	55/64 in.	22·0 mm.
1 1/8	7	31/32 in.	24·75 mm.
1 1/4	7	1 3/32 in.	1 3/32 in.
1 1/2	6	1 5/16 in.	33·5 mm.
1 3/4	5	1 17/32 in.	39·0 mm.
2	4 1/2	1 3/4 in.	44·5 mm.

B. S. F.

Nominal diameter of thread	No. of threads per in.	*Drill sizes to B.S. 1157:1944	*Drill sizes to B.S. 1157:1953
in.			
3/16	32	No. 23	5/32 in.
7/32	28	No. 15	4·65 mm.
1/4	26	No. 4	5·3 mm.
9/32	26	"B"	
5/16	22	"G"	6·75 mm.
3/8	20	"P"	8·25 mm.
7/16	18	3/8	9·7 mm.
1/2	16	11·0 mm.	7/16 in.
9/16	16	12·5 mm.	1/2 in.
5/8	14	35/64 in.	14·0 mm.
11/16	14	39/64 in.	
3/4	12	21/32 in.	16·75 mm.
13/16	12	23/32 in.	
7/8	11	25/32 in.	25/32 in.
1	10	57/64 in.	22·75 mm.
1 1/8	9	1 [in.	25·5 mm.
1 1/4	9	1 1/8 in.	28·75 mm.
1 3/8	8	1 15/64 in.	31·5 mm.
1 1/2	8	1 23/64 in.	1 23/64 in.

Tapping Drills for Metric Standard Threads

FRENCH AND D.I.N.

Nominal diameter of thread	Pitch	*Recommended Drill size
mm.	mm.	
2·0	0·45	1·5 mm.
2·0	0·4	1·6 mm.
2·2	0·45	1·7 mm.
2·3	0·4	1·9 mm.
2·5	0·45	2·0 mm.
2·6	0·45	2·1 mm.
3·0	0·6	2·4 mm.
3·0	0·5	2·5 mm.
3·5	0·6	2·9 mm.
4·0	0·75	3·2 mm.
4·0	0·7	3·3 mm.
4·5	0·75	3·7 mm.
5·0	0·9	4·1 mm.
5·0	0·8	4·2 mm.
5·5	0·9	4·6 mm.

Spark Plug

Nominal diameter of thread	Pitch	*Recommended Drill size
mm.	mm.	
10	1·0	9·0 mm.
12	1·25	10·8 mm.
14	1·25	12·8 mm.
18	1·5	16·5 mm.

S.I.

Nominal diameter of thread	No. Pitch	*Drill sizes to B.S. 1157: 1944 & recom.	*Drill sizes to B.S. 1157:1953
mm.	mm.		
6	1·0	5·0 mm.	5·0 mm.
7	1·0	6·0 mm.	6·0 mm.
8	1·25	6·8 mm.	17/64 in.
9	1·25	7·8 mm.	7·7 mm.
10	1·5	8·5 mm.	8·4 mm.
11	1·5	9·5 mm.	9·5 mm.
12	1·75	"Y"	10·25mm.
14	2·0	12·0 mm.	12·0 mm.
16	2·0	14·0 mm.	35/64 in.
18	2·5	15·5 mm.	39/64 in.
20	2·5	17·5 mm.	11/16 in.
22	2·5	19·5 mm.	49/64 in.
24	3·0	21·0 mm.	21·0 mm.
27	3·0	24·0 mm.	24·0 mm.
30	3·5	26·5 mm.	26·5 mm.
33	3·5	29·5 mm.	29·5 mm.

(Con't)

36	4·0	32·0 mm.	32·0 mm.
39	4·0	35·0 mm.	35·0 mm.
42	4·5	37·5 mm.	37·5 mm.
45	4·5	40·5 mm.	40·5 mm.
48	5·0	43·0 mm.	43·0 mm.
52	5·0	47·0 mm.	47·0 mm.

Tap Drill Sizes

BASED ON APPROXIMATELY 75% FULL THREAD

THREAD	DRILL
#0-80	3/64
#1-64	No. 53
#1-72	No. 53
#2-56	No. 51
#2-64	No. 50
#3-48	5/64
#3-56	No. 46
#4-40	No. 43
#4-48	No. 42
#5-40	No. 39
#5-44	No. 37
#6-32	No. 36
#6-40	No. 33
#8-32	No. 29
#8-36	No. 29
#10-24	No. 25
#10-32	No. 21
#12-24	No. 17
#12-28	No. 15
1/4-20	No. 8
1/4-28	No. 3
5/16-18	F
5/16-24	I
3/8-16	5/16
3/8-24	Q
7/16-14	U
7/16-20	W
1/2-12	27/64
1/2-13	27/64
1/2-20	29/64
9/16-12	31/64
9/16-18	33/64
5/8-11	17/32
5/8-18	37/64
3/4-10	21/32
3/4-16	11/16
7/8-9	49/64
7/8-14	13/16
1-8	7/8
1-12	59/64
1-14	15/16
1 1/8-7	63/64
1 1/8-12	1 3/64
1 1/4-7	1 7/64
1 1/4-12	1 11/64
1 1/2-6	1 11/32
1 1/2-12	1 27/64
1 3/4-5	1 35/64
1 3/4-12	1·43/64
2-4 1/2	1·25/32
2-12	1·59/64
2 1/4-4 1/2	2 1/32
2 1/4-4	2 1/4
2 3/4-4	2 1/2
3-4	2 3/4

TAPER PIPE

THREAD	DRILL
1/8-27	R
1/4-18	7/16
3/8-18	37/64
1/2-14	23/32
3/4-14	59/64
1-11 1/2	1 5/32
1 1/4-11 1/2	1 1/2
1 1/2-11 1/2	1 47/64
2-11 1/2	2 7/32
2 1/2-8	2 5/8
3-8	3 1/4
3 1/2-8	3 3/4
4-8	4 1/4
5-8	5 9/32
6-8	6 11/32

STRAIGHT PIPE

THREAD	DRILL
1/8-27	S
1/4-18	29/64
3/8-18	19/32
1/2-14	47/64
3/4-14	15/16
1-11 1/2	1 3/16
1 1/4-11 1/2	1 33/64
1 1/2-11 1/2	1 3/4
2-11 1/2	2 7/32
2 1/2-8	2 21/32
3-8	3 9/32
3 1/2-8	3 25/32
4-8	4 9/32
5-8	5 11/32
6-8	6 13/32

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Size	NET PRICE EACH			Overall Length
	High Speed Surface Treated Series 1180	Cobalt Series 1190	High Speed Polished Flutes Series 1170	
1/64"	[illegible]	[illegible]	$0.46	3/4"
1/32	[illegible]	[illegible]	0.31	1 3/8
3/64	[illegible]	[illegible]	[illegible]	1 3/4
1/16	[illegible]	[illegible]	0.29	1 7/8
5/64	[illegible]	[illegible]	[illegible]	2
3/32	[illegible]	[illegible]	0.28	2 1/4
7/64	0.20	[illegible]	[illegible]	2 5/8
1/8	[illegible]	[illegible]	[illegible]	2 3/4
9/64	0.24	[illegible]	[illegible]	2 7/8
5/32	0.27	[illegible]	0.34	3 1/8
11/64	0.30	[illegible]	0.35	3 1/4
3/16	0.34	[illegible]	0.40	3 1/2
13/64	0.38	[illegible]	0.45	3 5/8
7/32	0.44	[illegible]	0.51	3 3/4
15/64	[illegible]	[illegible]	[illegible]	3 7/8
1/4	0.50	[illegible]	0.57	4
17/64"	0.64	[illegible]	0.69	4 1/8"
9/32	0.69	[illegible]	0.73	4 1/4
19/64	0.78	[illegible]	0.82	4 3/8
5/16	0.82	[illegible]	0.90	4 1/2
21/64	0.88	[illegible]	0.98	4 5/8

Size	NET PRICE EACH			Overall Length
	High Speed Surf.Treated Series 1180	Cobalt Series 1190	High Speed Polished Flutes Series 1170	
11/32"	$1.04	$1.78	$1.10	4 3/4"
23/64	1.25	2.11	1.23	4 7/8
3/8	1.23	2.05	1.28	5
25/64	1.41	2.34	1.44	5 1/8
13/32	1.41	2.43	1.49	5 1/4
27/64	1.60	2.67	1.66	5 3/8
7/16	1.68	2.75	1.71	5 1/2
29/64	1.96	3.31	1.92	5 5/8
15/32	2.10	[illegible]	2.04	5 3/4
31/64	2.21	[illegible]	2.15	5 7/8
1/2	2.12	[illegible]	2.19	6
33/64	2.90	[illegible]		6 5/8
17/32	2.90	[illegible]		6 5/8
35/64	3.24	[illegible]		6 5/8
9/16	3.24	[illegible]		6 5/8
37/64	3.39	[illegible]		6 5/8
19/32	3.59	[illegible]		7 1/8
39/64	3.91	[illegible]		7 1/8
5/8	3.91	[illegible]		7 1/8
41/64	4.17	[illegible]		7 1/8
21/32	4.17	[illegible]		7 1/8
43/64	4.76	[illegible]		7 5/8
11/16	4.76	[illegible]		7 5/8

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Size	NET PRICE EACH			Flute Length	Overall Length
	High Speed Surf Treated Series 1189	Cobalt Series 1199	High Speed Polished Flutes Series 1179		
A	$0.59	[illegible]	$0.64	2 5/8"	3 7/8"
B	0.59	[illegible]	0.64	2 3/4	4
C	0.50	[illegible]	0.64	2 3/4	4
D	0.54	[illegible]	0.64	2 3/4	4
E	0.61	[illegible]	0.64	2 3/4	4
F	0.61	[illegible]	0.70	2 7/8	4 1/8
G	0.69	[illegible]	0.76	2 7/8	4 1/8
H	0.80	[illegible]	0.76	2 7/8	4 1/8
I	0.69	[illegible]	0.76	2 7/8	4 1/8
J	0.80	[illegible]	0.82	2 7/8	4 1/8
K	0.88	[illegible]	0.90	2 15/16	4 1/4
L	0.90	[illegible]	0.90	2 15/16	4 1/4
M	1.04	[illegible]	0.95	3 1/16	4 3/8

Size	NET PRICE EACH			Flute Length	Overall Length
	High Speed Surf Treated Series 1189	Cobalt Series 1199	High Speed Polished Flutes Series 1179		
N	$0.90	$1.50	$0.95	3 1/16"	4 3/8"
O	0.88	1.64	0.95	3 3/16	4 1/2
P	1.08	1.64	1.08	3 5/16	4 5/8
Q	1.08	1.78	1.08	3 7/16	4 3/4
R	1.04	1.78	1.16	3 7/16	4 3/4
S	1.41	2.22	1.22	3 1/2	4 7/8
T	1.53	2.22	1.37	3 1/2	4 7/8
U	1.30	2.22	1.37	3 5/8	5
V	1.53	2.43	1.42	3 5/8	5
W	1.49	2.43	1.47	3 3/4	5 1/8
X	2.10	2.43	1.80	3 3/4	5 1/8
Y	2.31	2.43	2.09	3 7/8	5 1/4
Z	2.39	2.81	2.16	3 7/8	5 1/4

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ELECTRIC SELF WINDING CLOCK.

No. 405,089. Patented June 11, 1889.

Fig. 2.

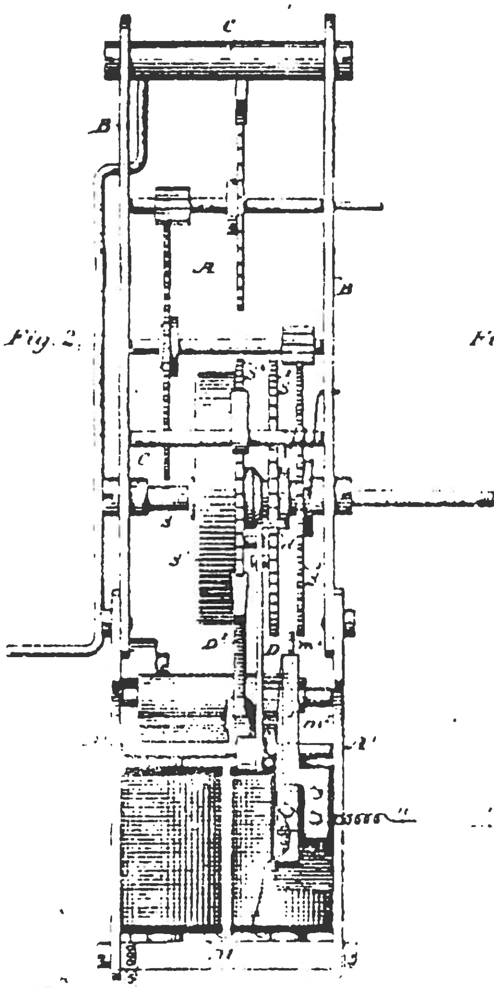
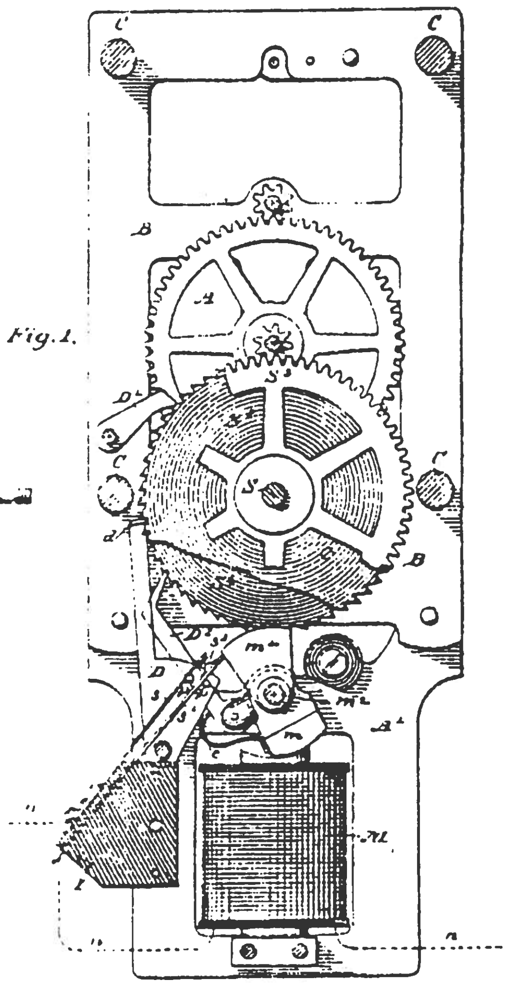


Fig. 1.



Witnesses

Geo W. Breck.

Carrie E. Ashley

Inventor

James H. Gerry

By his Attorneys

Pope Edgecomb & Terry

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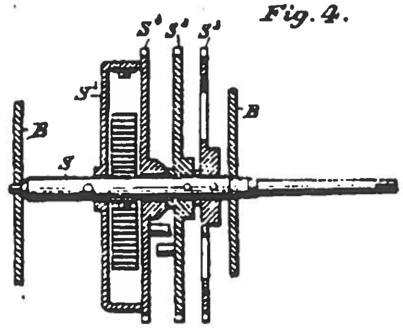
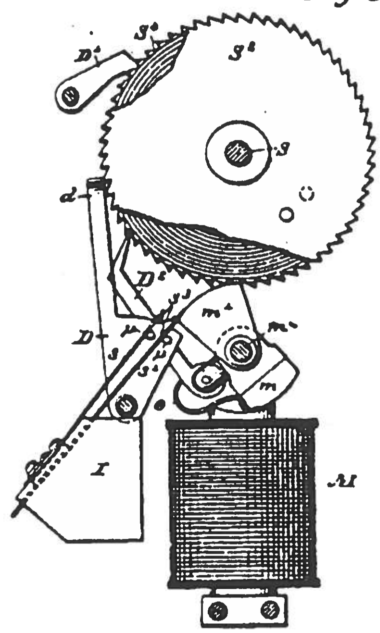
No. 405,089. Patented June 11, 1889.





Witnesses
Geo. W. Breck
Carrie E. Ashley

Inventor
James H. Gerry
By his Attorneys
Pope Edgecomb & Terry

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The JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY Chapter No 78

NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

VOLUME XVII, #4, DECEMBER 1991

Fellow Horologists:

Our final issue of 1991 is special in many ways... The major section is given over to Charles K. Aked's comprehensive list of English clock patents from 1840 to 1900. This work involved a tremendous amount of research and we are greatly indebted to Mr. Aked for his kind permission to use it. We have taken the liberty of binding the material as a separate monograph, apart from the balance of this journal's material. Review this information and note the comments covering the essentials of the individual patents, and take note additionally of the index by patent holder's names, and Mr. Aked's introduction, as well.

Included with this issue is a pocket calendar/diary for 1992... last year's was well received in spite of its tardiness, so we have repeated the printing again. Also included is the 1992 DUES NOTICE... unchanged, and still a bargain at only $10.00! Please get your remittances out promptly... It becomes a real nuisance to delete a name for non-payment, and then later in the year, add it back again simply because of neglect in prompt payment. Thanks in advance for your cooperation.

A meeting of the Chapter 78 membership has been scheduled for March 29th at the home of Dr. & Mrs. Levy. We suggest that an RSVP call be made a week or two in advance of that date to confirm attendance and receive travel instructions and their address. The phone number is 516-433-6836 which is in the Long Island area of New York, for those who are not local, but may be in the neighborhood at that time. Additional Electrical Chapter meetings are planned for the Ft. Mitchell, KY Regional, April 10th & 11th, and at the National Convention in Chicago, July 1st thru 4th. As an aside, the exhibit theme at the national will be Electrical Horology, and the display promises to be an outstanding one, not to be quickly forgotten. If you would like to enter a clock in the exhibit, contact Bill Keller, or Elmer Crum. Contact Linda Brusky at 312-486-2406 for details.

In closing, the officers and editorial committee wish to extend their warmest Holiday Season Greetings along with their best wishes for a Prosperous and Healthy New Year.

Martin Swetsky, FNAWCC, President
Dr. George Feinstein } Co-Editors
Harvey Schmidt }

Galvani's original electro-physiological work in the late 18th century inspired a whole new wave of experimentation. Here, someone makes an attempt to generate animal electricity by sliding a pair of frog's legs across the tongue of a dead bull.

Could this power a clock?

Maybe someone will continue with Galvani's original experiments, and attempt to generate "Animal Electricity"...

Along the lines of scientific interest, we'll publish the ongoing results...

--- MART ---

All MART Ads are FREE. Send copy to the attention of the Editor:
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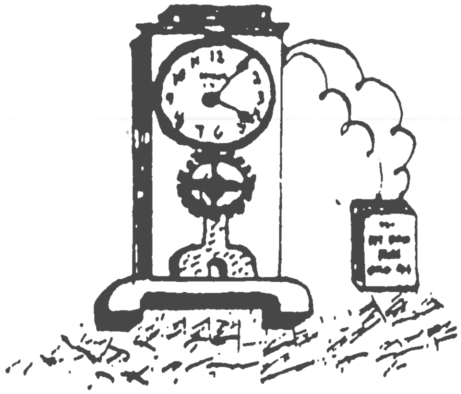
Steve Lefkowitz, 13 Puritan Park, Swampscott, MA 01907

ELECTRICAL HOROLOGY SOCIETY

Chapter No 78



RENEWAL MEMBERSHIP or APPLICATION FORM

The Electrical Horology Society--Chapter 78 was formed in 1972 to provide a means whereby members of the NAWCC who have a primary and strong interest in early battery clocks as well as A.C. clocks would have a means to meet and communicate with other members having similar interests. Due to the geographic locations of the membership, our Chapter's cohesiveness depends upon two factors. One, we print the JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY six times per year with a yearly total of 72 pages of material. The JOURNAL includes technical information, original articles, reprints of important articles found in sources not generally available to the average collector, a question and answer section, a mart and other pertinent information. Secondly, we encourage groups of members to meet and form "Branches" of our Chapter. Local branch meetings include an educational program, a trouble-shooting discussion and often a small mart.

Any member in good standing of the NAWCC is eligible to join our Chapter. Our fiscal year begins in December and members joining after that date during the year will receive all the back issues for that year.

DETACH ALONG THIS LINE

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Send check to Harvey Schmidt, 75-80 179th Street, Flushing, NY 11366, and make payable to EHS #78, % Harvey Schmidt, Secretary-Treasurer.

NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY

VOL. XVII #4, DECEMBER 1991

ELECTRIC CLOCK PATENTS 1840/1900

COMPILED BY CHARLES K. AKED

CONTENTS

ELECTRIC-CLOCK PATENTS

FOR THE PERIOD 1840-1900

ELECTRICAL HOROLOGY PATENTS

INTRODUCTION:

There is a wealth of ideas, material, and information locked up in the Patent Specifications drawn up by the hopeful applicants intent upon protecting their inventions and, hopefully, about to make their fortunes from a grateful and admiring populace. Alas for those who put their faith and effort into electrical horology, the rewards were in general extremely meagre, the most successful entrepreneur probably being Frank Hope-Jones. Yet even for him the most important production of his search for perfection, the free pendulum clock designed for him by W. Hamilton-Shortt, amounted to only one hundred examples, all made by the same craftsman. Not one of these is fulfilling the task for which it was designed originally, the accuracy of performance being totally inadequate for the needs of today. Hope-Jones' firm was sold when he became too old to continue to manage it himself, and after take-overs its eventual successor only has a slight interest in electrical clocks, having expanded into other more profitable interests. Gents of Leicester, again one of the more successful firms dealing with electric clocks, have had to branch out into other electrical lines to survive, although electric clocks were not at first made by them.

We have to thank Bennet Woodcroft for the foundation of the Patent Office in 1852, and for his indefatigable efforts to bring order into the muddled chaos of the patent system. Within five years of taking office he had printed all the old specifications, making the information available to all by 1857.

The interests of electrical horologists are not aroused until the year 1841 when Alexander Bain filed his application with the help of finance from John Barwise. It must be admitted that there is a lot of chaff hiding a few grains for anyone ploughing through the Abridgments of Patents, for it is too expensive and too time consuming to examine each Patent Specification individually; they will find themselves weary of the same old formula for an electric clock repeated ad nauseum: only occasionally does a new idea emerge. Essentially the first of Alexander Bain's patent specifications covered all the fields which were to emerge later, apart from those he could not possibly have foreseen, such as quartz crystal and caesium clocks.

Basically the idea of electric clocks, ignoring all the early efforts to make a successful one operated by static electricity; was to be part of the use of telegraph lines, the transmission of time signals to improve the usefulness of the spreading communication system. The time was ripe for such developments, railway lines spread, together with their associated telegraph and signal lines, and the need to unify the time system of the whole country to allow the modernisation of the transport system to proceed and avoid the exposure of the traveller to a new local time in every town and city, amalgamated all the necessary ingredients to achieve success when the new forms of electrical power were being made available, such as Professor Daniell's two-fluid cell in 1838. These provided the first sources of current electricity in sensible and constantly available amounts at relatively low cost from fairly harmless chemical solutions, unlike some versions using large platinum plates and fuming nitric acid as a depolariser. The source of electric power had to be cheap and reliable if it was to be applied to horology.

We have to thank Frank Hope-Jones too for the interest he took in examining electrical horology patents, even if it was an accidental product of his own searching for ideas for his own electric clock systems. After his estrangement from his early partner G.B.Bowell, the inventive input was greatly reduced whilst the selling was greatly increased, and an analysis of the Hope-Jones' developments in later years does not show much advancement except in conjunction with other researchers. He became obsessed with the idea that his Synchronome switch was the answer to all electric clock problems, and that it was a principle rather than a solution. As he neared the end of his life he realised that all the effort to bring the electrically maintained pendulum as close to perfection had been brought to naught by the development of the quartz crystal clock, yet he had no regret, as may be discerned from a note written on a Christmas card sent to the Institution of Electrical Engineers during the war years. Practically alone of the horologists in the early part of the twentieth century, he recognised that specimens of electrical horology should be preserved for posterity, most examples being consigned to the dustbin as old-fashioned and useless failures which had cost more initially than an ordinary mechanical clock, never worked properly, used expensive batteries which leaked corrosive liquids and damaged the clock and case, and totally impossible to have serviced since ordinary clock repairers would not touch them and ordinary electricians ruined them with their lack of horological knowledge. Many examples of electric clocks were presented to the Science Museum, and we must be grateful that the authorities in the Museum had sufficient faith or judgement to accept them and eventually place them on display. Today the electric clock collection in the Science Museum is probably the most comprehensive and best in the world.

F. Hope-Jones put his researches into patent history to further good use when he compiled his famous book Electric Clocks, published in 1931; later to become Electrical Timekeeping, first published in 1940. Contained in its pages are details of the most important stepping stones in the patent progression, plus the developments that occurred without their inventors seeking patent protection, those in the search for ultimate perfection for its own sake. Without doubt, there is no better book dealing with electrical horology patents than that written by Hope-Jones, and we can forgive him his errors, his hobby horses, and even his unjust condemnation of Alexander Bain, who in perspective was a far greater man in the field of electrical horology. Alexander Bain was the first man to harness current electricity to maintain a pendulum in motion at a time when electrical science was in its infancy, and when the common units in force today, volts, amperes, and ohms were not even known as concepts.

Very few enthusiasts would be able to afford to purchase all the copies of the actual patents, the cost up to 1930 would be well over one thousand pounds, nor for that matter even the original Abridgments of Specifications, now quite rare and expensive to obtain. Fortunately for enthusiasts Albert L. Odmark published all the Patent Specification Abridgments for the period 1855-1900 and 1901-1930 in two excellent volumes in 1979, Class 139 - Watches, Clocks and other Timepieces. This is much the most important period for enthusiasts since examples of the earliest electric clocks rarely turn up for collecting, and only nine patents for electrical horology were issued before 1855. For his own use, the writer has produced this present list giving the briefest details of all the known electrical horology patents from the beginning up to and including 1900, approximately four hundred patent specifications. To cover this period has taken a great deal of time as in the later years there may be as many patents in one year as in the first twenty-five years altogether, the highest number being thirty-four in 1927. As there are almost one thousand patents for electric clocks from 1841 to 1930, the size of this list would have been almost trebled and completely uneconomic to reproduce. It is unfortunate that many of the patents applicable to the well known collectors' clocks come into the later period, the Eureka, the Murday, the Bulle, etc. The purpose of the present list is to enable some knowledge of the lesser known ideas to be gained rather than the well-known examples; and for the first time there is a list of all the inventors taking part up to 1900 for consultation without the need to plough through numerous pages to find them piecemeal.

Since the descriptions are necessarily very brief to make this list of manageable proportions, the entries can be no more than an indication of the contents of a patent specification, for in general each applicant sought to make the patent cover all the variations possible to avoid its being circumvented and avoid costly legal arguments should the patent be infringed. This makes some of the additional suggestions to the central idea rather fatuous at times but a patent offers no protection if it can be got round by a simple modification. Nevertheless the Patent Office supervisors seem to have been very lenient in their treatment because there are very few original concepts embodied in the majority of electrical horology patents, many of which essentially describe what has gone before, and in some case the application of electricity is very slight indeed, sometimes amounting to no more than a suggestion that an electric bell might be connected in lieu of a mechanically operated bell. The list is a signpost and no more, a collation of all the applications of electricity to horology sifted out from all the other horological patents in the period of 1840 to 1900. It could have been dissected, analysed and tabulated, but those who have read Hope-Jones' books will already be aware of the historical importnca and usefulness of the devices briefly entered here. Electricity in all these applications is used as a simple means of producing a more simple solution than equivalent mechanical means, but apart from illumination purposes, it is used to produce an electromagnetic effect, locally or at a distance to maintain balances or pendulums in motion, or to drive clock trains by a spring or weight periodically restored from low potential energy to a higher potential energy, to rewind mainsprings of going and winding trains; and the great goal of the late nineteenth century, synchronization of all the clocks within a system by pulses sent out from a precision timekeeper. What a boon for example for an observatory to have the identical time available at any desired point, and requiring only a thin wire connection to achieve this miracle. So basically electrical horology has as its foundation the attraction of a soft iron core on a soft iron armature when an electric current passes through a solenoid wound on the soft iron core. This principle of a material which can be made magnetic or non-magnetic at will by a small electric current is central to the theme of electrical horology; all other details are merely to achieve the desired actions as a result of an armature being attracted or released, or the equivalent of an armature giving rotary motion. Attempts were made to use the heating effect of an electric current to drive clocks, some being quite successful; these must be regarded as properly belonging to the class of clocks operating on a pneumatic system since the heating effect could be obtained by any convenient means.

Electricity gave many inventors an entry into horology since even crude electrical mechanisms can be made to give quite good timekeeping, before the last war many amateurs made pendulum clocks using the ancient Hipp toggle switch and an old alarm clock driven by a gravity arm moved by the pendulum, achieving an accuracy of rate comparable or better than most of the commercial mechanical clocks which had a variable rate if spring driven and going for a week on one winding. To produce a mechanical timekeeper of equivalent or better performance requires a very much higher standard of knowledge and workmanship and beyond the abilities of most amateurs, whereas an electrically operated clock needs only a precision pendulum and a satisfactory means of maintaining it in motion, all the time indications can be provided by the use of comparatively simple and crude mechanisms in any suitable position desired, crude that is compared with the exquisite work of a precision weight driven regulator or marine chronometer

Some references:

Alphabetical Index of Patentees of Inventions 1617-1852, by Bennet Woodcroft, first published in 1854 and reprinted with corrections by D. R.Jamieson, Assistant Keeper at the National Reference Library of Science and Invention. This work covers all the patents in all fields up to 1852. A magnificent work, even if the entries are rather terse in places.

Complete List of English Horological Patents up to 1853, Charles K. Aked, 1975. Brant Wright Associates Ltd., Ashford.

Electrifying Time. a catalogue of the Exhibition held at the Science Museum December 1976 to April 1977. Compiled by Charles K. Aked. A.H.S. Monograph No. 10. Especially see the bibliography included on pages 19-20.

Patent Abridgements - Horology 1855-1930 in two volumes, (1855-1900) and (1901-1930), facsimile reprint from the original Abridgments of Specifications, Class 139, Watches, Clocks, and other Timekeepers. Published by Albert L. Odmark, Seattle, U.S.A., 1979. A necessity in any horologist's library.

Charles K. Aked.

ELECTRICAL HOROLOGY PATENTS

1841	11.1.1841 8783 Bain, A. & Barwise, J.	The first electrical horology patent taken out by Alexander Bain, J. Barwise providing the necessary finance, Bain being without resources of his own. The ideas listed in his patent are too numerous to list here since nearly all the later developments in electrical horology were anticipated by this single compendium patent. These original conceptions are listed briefly in the Electrifying Time exhibition catalogue published March 1976, Monograph no. 10; or in A Conspectus of Electrical Timekeeping, 1976, Monograph no. 12. This patent would have been the first in the world had not Queen Victoria been confined, at that time the sovereign's signature was legally necessary. Steinheil's patent in Germany therefore has the honour of being the first patent granted although not the first submitted.
	21.12.1841 9204 Bain, A. & Wright, T.	Application of electricity to control railway engines, mark time, give signals and print intelligence at distant points. It would seem that Alexander Bain was seeking to establish priority in this and later electrical horology patents since there is little evidence of practical devices ever being made on the lines of these patents.
1843	27.5.1843 9745 Bain, A.	Production and regulation of electric currents, electric timepieces, electric printing and signal telegraphs. The first electric horology patent taken out by Alexander Bain financed from his own pocket.
1845	25.9.1845 10838 Bain, A.	Electric clocks and telegraphs. These later patents of Alexander Bain were more biassed to practical use than than to original concepts and fundamental principles, but little survives of the equipment to these designs.
1847	19.2.1847 11,584 Bain, A.	Electric timekeepers and clocks, and apparatus connected therewith.
	23.4.1847 11,634 Hatcher, W.H.	Electric telegraphs, apparatus connected therewith, electric clocks and timekeepers. The first electric horology patent taken out by a worker independent of Alexander Bain.
* 1849	16.4.1849 12,567 Shepherd, C.	Working clocks and other timekeepers, telegraphs and machinery by electricity. A clock made on the principles in this patent may be seen at the Old Observatory, Greenwich, it was made in 1852. A gravity arm drops on the pendulum at each alternate swing and is reset by an electromagnet, ther clock itself provided the time signal from its installation in 1852 until 1893, and it is in operation today, also one of the slave dials at the entrance gate. The principle was anticipated by Alexander Bain.
	18.7.1849 12,711 Brown, W. Mapple, H. Williams, W.	Communicating intelligence by electricity, electric clocks. A second patent was taken out in 1860 by H. Mapple in conjunction with W. Morris. no. 1515 of 22.6.1860 and given provisional protection only.
1852	29.5.1852 14,146 Bain, A.	Electric telegraphs and electric clocks and timekeepers, and the apparatus connected therewith. The last patent connected with electric horology taken out by Alexander Bain.

Between this last date and the end of 1855 there were no approvals for electrical horology patents.

ELECTRICAL HOROLOGY PATENTS

1855	21.12.1855 2895 Tyer, E.	Chronograph incorporating a polarised relay controlled by a signalling current. the recording surface marked by the relay action being driven by ordinary clockwork.
1856	5.1.1856 45 Kammerer, R. & Brewer, C.	Electrically operated pendulum consisting of two electromagnet cores placed so that a piece of magnetised steel on the pendu-rod can pass between to be alternately attracted and repulsed. The electromagnet current is reversed by a commutator fixed on the escapement wheel turned by the pendulum.
	23.7.1856 - 1751 Detouche, C.L. Houdin. J.J.E.R.	Street and other lamps provided with dials driven electrically from a standard clock. (Provisional protection only).
	19.8.1856 1933 Osman, H.F.	Electrically operated weight remontoire acting on a pendulum with an electromagnetically operated slave clock impulsed at second intervals and having a sixty-tooth count wheel. A pin on this wheel drives a star wheel which moves the hour hand. (Communication only).
	19.9.1856 2205 Hees, R.van. (Kammerer, R)	This is a revised version of Patent No. 45 of 5.1.1856. The first version mentions the use of plates of metal in the earth or a battery, the former is not mentioned in the second version. It adds that the parts connecting the working parts to the hands are to be made of glass to allow illumination of the dial without the casting of shadows on the dial.
* 1857	11.3.1857 702 Jones, R.L.	This is the famous patent of R.L.Jones, Station-Master of Chester Station, for the synchronization of independently driven pendulum or balance wheel clocks from a central precision regulator using a battery and an earth or wire return to complete the circuit. It was not successful.
* 1858	2,6.1858 1241 Wheatstone, C.	Wheatstone suggests that his step by step telegraph may be used for electric clocks by substituting hour figures for the letters. the arbor being the seconds hand drive and a train to give hours and minutes. The controlling clock transmits current reversals from a battery. (Drawings to the specification were supplied).
1859		No electrical horology patents were applied for in this year.
1860	23.2.1860 486 Mapple, D.M.	Clock with electrically driven pendulum impulsed by a weight lifted by an electromagnet and held by a permanent magnet and released by the action of a second electromagnet for impulse.
	22.6.1860 1515 Morris, W. & Mapple, H.	Impulse spring or weight arranged to give impulse to the pendulum when the pendulum is moving in the direction of the impulse. The electromagnet which gives motion to the clock train also raises the weight or tensions the spring. (Provisional protection only).
	10.12.1860 3032 Johnson, J.H. (Guichene, F.)	Separate striking mechanisms controlled from an ordinary clock by an electric circuit. the striking mechanisms appear to be ordinary weight or spring driven trains released by a detent acted on by the motion of an electromagent armature. (Provisional protection only).
1861	29.11.1861 3015 Tyer, E.	Mechanism employed in step by step dial telegraphs applied to electric 'sympathetic clocks'. A notched and split soft iron ring polarized by a permanent magnet is made to oscill-ate by alternate currents in the signal wire.

ELECTRIC HOROLOGY PATENTS

1862 *	21.1.1862 161 Henry, M. (Guyard, F.V.)	Synchronization of a large number of clocks from a standard clock by sending impulses at minute intervals to different groups. Further regulation can be obtained by the use of relays in the first controlled clocks. The clocks are set to gain and corrected by being arrested and released at the end of each hour.
	15.2.1862 404 Johnson, J.H. (Koosen, J.H.)	Electric motor controlled by a centrifugal contact breaker to constant speed to drive a clock train. The arbor of the seconds wheel carries contacts to control one or more secondary clocks. Provisional protection only granted, see next entry.
	15.8.1862 2305 Johnson, J.H. (Koosen, J.H.)	The previous entry with slight modifications and a diagram supplied showing the arrangement. This diagram was often shown in encyclopaedias. A Daniell cell was used to provide the power.
1863	6.3.1863 633 Jourdin, M.	Electric engraving machine for decorating watch dials and cases. The engraver is controlled by an electromagnet adjusted towards or from the work in a rotating frame and a metallic tracer moves over a rotating pattern plate filled in with an insulating material. Provisional protection only.
1864	21.1.1864 169 Ritchie, F.J.	A soft iron inductor produces currents in coils mounted on permanent magnets, the inductor being mounted on the arbor of a standard clock with a Denison gravity escapement. The system synchronizes small pendulum or balance wheel clocks, for large clocks the pendulum is dispensed with and the escapement of the synchronized clock controlled directly. Mention is made of the rectification of alternating currents by a commutator or reversing switch.
	1.9.1864 2147 Johnson, J.H. (Baudet, P.)	A bell-ringing mechanism is separate from a clock but the alarm is released by a detent controlled by the clock. This lever may be arranged to ring other bells simultaneously by the use of an electric circuit.
	27.9.1864 2362 Clark, W. (Lesieur, A.J.B. & Prud'homme, P.D.)	An electromagnet is placed below and to one side of a pendulum and is impulsed at intervals of time equal to the time of oscillation of the pendulum. A lever attached to the top of the pendulum has its remote end resting on a knife-edge, and is notched so that a ratchet wheel is moved tooth by tooth, a hinged weighted lever acts as a back-stop to prevent reverse motion.
1865 *	2.5.1865 1230 Siemens, C.W.	A liquid governor carries a rotating armature and commutator on its shaft with two vertical electromagnets to control the mechanism when used as an electric clock. A worm on the same arbor drives the clock train, and the clock itself is mounted on a pedestal which holds the battery.
	2.6.1865 1518 Brooman, R.A. (Scholte, J.T.)	Electrically maintained pendulum operating a toggle switch when the amplitude falls to a designed minimum amount. An electromagnet below the pendulum attracts a soft iron armature secured to the end of the pendulum. A double-armed lever rotates a wheel turning a worm on the same arbor to drive the minute hand wheel. Basically the well-known Hipp toggle device.
	16.12.1865 3260 Reade, C.L.W.	An iron wheel carries eight or more armatures and is rotated by the armatures being moved in and out to unbalance the wheel, electromagnets being used to move the armatures. The speed of the wheel is regulated by clockwork and the resulting power used to drive timekeepers. Awarded provisional protection only. No diagram.

ELECTRICAL HOROLOGY PATENTS

1866	15.1.1866 136 Newton, A.V. (Levin, M.)	Pendulum or balance wheel interruption of an electrical circuit to maintain oscillation and rotate a seconds wheel turning a train with motion work to turn minute and hour hands. The balance wheel arbor carries a cam which causes two spring contacts to close.
	22.2.1866 549 Bright, H.	This well known design utilised a weight-biassed lever to make contact with contacts fitted at each side of a pendulum near the suspension spring. A solenoid fitted under the pendulum and swinging over two permanent magnets, had the current through its energising circuit reversed at each swing of the pendulum. A similar arrangement without the contacts could be placed in series and kept in step. For turret clocks a double contact maker was used to drive the pendulum in both directions.
	26.5.1866 Weatherdon, B.F. (Durand, J.J.M.)	An electrical self-regulating system controlled by thermometric means and stated to be applicable to "clockwork". A diagram shows it arranged for controlling a damper or valve, but the application to a clock is not described. (Not strictly horological, no.1470).
*	5.9.1866 2285 Newton, A.V. (Bruyssel, E. van)	Newton's design consisted of a commutator connected to an ordinary clock on an arbor turning once in two minutes. Groups of indicating dials received currents periodically reversed by platinum projections on two ivory insulated discs, or the use of an ivory cylinder, dipping into mercury to complete the circuits as required. Another arrangement uses clockwork to rotate a magnet between coils to provide power to the indicator clocks, anticipating the Magneta clock.
1867	2.5.1867 Bonneville, H.A. (Delay, V.) 1275	Means of actuating and synchronizing private clocks from public clocks. The galvanic battery is placed at stated distances in series so that the electric current is constant. The motion of the slave dials is with the oscillation of a lever and and an anchor. A commutator on the arbor of the escape-wheel of the public clock makes and breaks the electric current. The letters patent became void for want of the Final Specification.
	23.5.1867 Theiler, M. Theiler, R. Theiler, M. 1531	Electromagnetic apparatus applicable to electric clocks. Electromagnets and armatures act on a bar to cause oscillations from a central position. Intermittent or reversing currents are used, a primary clock with suitable contacts effecting the pulses. Provisional protection only granted.
	4.6.1867 1641 Inshaw, J.	An arrangement for short-circuiting the current through the electromagnets of a master clock or slave clock should the amplitude of the pendulum become too great. The arrangement can be varied to divert the current as required. Anticipated by Alexander Bain.
1868	23.7.1868 2317 Harrison, W.S.	A series of clocks are synchronized each hour by current from a primary clock for a few seconds. An electromagnet in each subsidiary clock attracts an armature which releases the fly of a special setting mechanism. At the hour the current ceases and the mechanism is reset for the next operation.
	12.8.1868 2523 Rapier, R.C.	The primary clock of an electric system consists of a pendulum and contacts only, all gearing and hands being dispensed with. Currents are transmitted from this pendulum to controlling pendulums at a series of railway stations or towns, from these groups of clocks are controlled. Two or more sets of contacts are fitted so that the current pulses are not missed through grease or dirt. Provisional protection only.

ELECTRICAL HOROLOGY PATENTS

1868	30.11.84 3641 Green, R.A.	For obtaining relief decorations for watch cases, a relief is used to make a cast of the design, this is then placed in an electrolytic bath and any of the usual metals plated on the cast. Copper may be deposited first, followed by gold or silver.
1869	8.3.1869 698 Cook, H.W.	A regulating device to synchronize secondary clocks by having pendulum controlled clocks set to gain. At intervals an electric contact on the master clock transmits a current to energise an electro-magnet in the controlled clock which holds the pendulum at the end of its swing, releasing it at the correct moment.
	25.3.1869 919 Bonneville, H.A.	Design for an electric clock which is almost an exact copy of Alexander Bain's design. A bar magnet mounted on the end of the pendulum enters a solenoid coil at each extremity of swing, and the electrical contacts placed halfway up the pendulum rod are actuated by a bar slider.
	20.5.1869 1560 Rossignol, A.A.	One of the first designs for a self-winding clock, where the mainspring is wound via a ratchet wheel by the action of a magnet controlled by contacts closed by a wheel in the train. In a modified version, a distant regulator controls the current and the auxiliary spring is dispensed with.
*	18.10.1869 3028 Stroh, J.M.A.	This patent anticipates the use of a solenoid swinging on the end of a pendulum over a permanent magnet by Charles Wheatstone, but again anticipated in design and use by Alexander Bain. The design also includes a method of synchronizing the clock at a certain time of the day, with a method of regulating the main pendulum by a auxiliary pendulum swinging with the main pendulum. The secondary clocks have an astatic needle mounted on an arbor to drive a train the needle is turned by alternately reversed currents from the regulator clock.
1870	25.8.1870 2339 Newton, W.E. (Bonhomme, E.)	Design for a regulator clock which is rewound electrically by the action of an armature of an electromagnet turning a ratchet wheel through a pawl. This wheel turns a train by winding a spring on the arbor of the second wheel. A similar arrangement can be used striking, for turret clocks, and for room clocks.
	28.9.1870 2578 Lake, W.R. (Andrews, E.W.)	An electromagnetic relay which is polarised magnetically and the contacts opened by a control current passing through a winding on a soft iron core to neutralize the permanent field. This is said to be useful for use with chronographs and astronomical observ-ations requiring time repeaters.
*	23.11.1870 3069 Thomson, Sir W. Lord Kelvin	Part of this patent application is concerned with applying elect-rical connections to the centrifugal governor used by Lord Kelvin to allow it to be driven by an electric motor, the speed of which is normally too high, and when electrical contacts close, the speed reduces; the correct condition being obtained by hand-set resistors. It also mentions the use of rewinding of the clock train by the energy from the striking train. (Provisional protection was not allowed for some reason).
* 1871	25.3.1871 810 Thomson, Sir W.	This again deals, but more briefly, with the use of Lord Kelvin's centrifugal governor, and principally concerns the control of the speed of an electric motor in order to achieve almost constant speed of rotation, the final correction being by a compensated pendulum with a zinc rod and platinum wire. (Letters patent void for want of Final Specification).

ELECTRICAL HOROLOGY PATENTS

* 1872	15.2.1872 473 Wheatstone, Sir C. & Stroh, J.M.A.	Describes a step-by-step telegraph instrument which may be adapted for telegraph clocks, the arrangement consists of an arbor with pallets progressing an escape wheel of a spring driven clock in response to external signals. The diagram showing the electromagnet arrangement is not at all clear.
	10.7.1872 2078 Ritchie, F.J.	Secondary clocks with sympathetic pendulums receive impulses from electrical contacts fitted to a standard regulator. The seconds pendulums fitted to the secondary clocks lift and release pallet arms, in the case of a half-second pendulum, only one arm is used. These pallet arms act like gravity arms and propel an escape wheel. Balance wheels may also be employed.
	9.10.1872 2970 Mills, B.J.B. (Davis, W.M.)	A master clock is driven by two impulse weights acting alternately on a short cross-piece fixed to the top of the pendulum, the weights being reset by an electromagnet. Behind the pendulum about half-way up, is a fork lever operating contacts to control secondary clocks, these are fitted with electromagnetically maintained pendulums and operate an escape wheel in reverse to drive a clock train. Mercury is used to provide contact to moving parts, and the electrical contacts are immersed in kerosene or oil to prevent oxidisation.
1873	25.2.1873 706 Newton, A.V. (Milde, C.F. & Vimard, L.C.)	Relates to the driving and winding of clocks by electricity, especially applicable to a ship's clocks. The armature of an electromagnet rewinds a mainspring through a pawl and ratchet wheel. Contacts are fitted to allow the clock to act as a master clock for a group of secondary clocks, the electromagnet armature closing contacts at each rewinding action.
	12.5.1873 1717 Harrison, W.S.	Five proposals are delineated, firstly the use of telegraph wires for very short periods to transmit time signals, secondly the protection of electric clocks from the influence of electric currents other than the time signals, thirdly a method for improving electrical control of clocks, fourthly recording time signals, fifthly the means of connection and disconnection from a line without breaking the continuity. (Provisional protection was not allowed).
	16.7.1873 2446 Holten, S.E. & Varley, F.H.	Electric clock fitted with one or two auxiliary pendulums fitted to the main pendulum to give maintaining power and to close contacts to drive a time recording apparatus. A dial plate or roller driven by the clock to turn once in twelve hours, carries on its surface a paper which is perforated by an electromagnetic marker operated by the apparatus being monitored, turnstiles, machinery, watchmen, etc.
	10.9.1873 2969 Moseley, W.	Relates to marine signalling apparatus which may be used as a relay in clocks, basically a step-by-step transmitter and receiver worked by permanent magnets and electromagnets. The exact application is not specified.
1874	7.3.1874 Browne, J.C. (Herlert, R. partly)	Synchronizing of electric clocks from a standard clock using contacts operated by some part of the standard clock. The secondary clocks close a circuit to indicate their functioning, trains of wheels are dispensed with, and lastly the hands are locked for a short period after each movement. A ratchet wheel of sixty teeth to turn the minute hand directly with impulses every minute is preferred.
*	25.4.1874 1442 Wignall, J.W.	A self-winding apparatus using a battery of the bichromate type to energise an electromagnet to raise a weight by a pawl and ratchet wheel. The fall of the weight depresses a plunger which raise the electrolyte level to actuate the battery, or lowers the electrodes into the electrolyte. A supplementary weight compensates for the weight of the zinc electrode.

ELECTRICAL HOROLOGY PATENTS

* 1874 30.4.1874 1505 McKellen,S.D. — A pendulum carries a toggle to actuate contacts as in the Hipp design, the impulse being given by a freely falling weighted lever acting on the top of the pendulum, this being released by an electromagnet operated by the contact closure. After giving impulse the electromagnet de-energises and and its weighted armature resets the weighted lever ready for the next operation when the pendulum arc falls to the designed minimum amplitude. This arrangement gives a constant impulse regardless of the driving battery voltage.

5.8.1874 2717 Haseltine,G. (Cook, H.O.) — A method of illuminating clock dials by the luminous effect of electricity passing through a highly evacuated glass tube, these may be fitted with internal tubes containing fluorescent materials to enhance the light output. The high voltage necessary is provided by an induction coil and a battery. Given provisional protection only.

9.9.1874 3089 Greenwood, H.B. — An electrically maintained balance-wheel clock, the balance wheel carries a pin working in a lever whose pivot is surrounded by a small disc of platinum and ebonite fitted close to another small metal disc which oscillates on a pivot and is connected to the positive pole of a battery. A small pin on this disc contacts the platinum and ebonite disc portions alternately, when in contact with the platinum an electromagnet pulls the balance lever to give an impulse. Another electromagnet propels a ratchet wheel tooth by tooth to register the time. Granted provisional protection only.

1875 26.6.1875 2335 Conad, A. — A regulator clock closes a circuit each minute to actuate secondary clocks, these are fitted with striking mechanisms driven by electromagnets controlled by contacts fitted to the striking mechanism of the regulator clock. A second electromagnet is used to lock and free the secondary clock ratchet wheel.

18.8.1975 2921 Johnson,J.H. (Gondolo,E.J.) — Secondary clocks are synchronised by controlling the anchor escapement of a spring driven clock by an electromagnet acting on the pallets, and a given number of impulses passed each minute from a primary clock. No pendulum is fitted to the secondary clocks.

4.12.1875 4206 Lake,W.B. — A small electric battery is fitted to a clock and heats a platinum coil to ignite a small lamp or match as required.

1876 14.1.1876 162 Harling, W. — A magnetic escapement driven by a soft iron bar attracted by an electromagnet. As the bar moves to and fro, a fork attached to it moves a wheel tooth by tooth, the wheel being locked by pressure from the armature or a return spring alternately. A contact on the armature makes and breaks the electromagnet circuit, or a master clock can be used to regulate it.

29.2.1876 843 Jensen, P. — A vibrating tuning fork transmits a series of isochronous currents through telegraph lines or other electrical conductors for regulating clockwork.

19.5.1876 2119 Carpenter,J. Martin,G. — A rewinding mechanism for a spring clock where an electromagnet acts on an armature driving a ratchet wheel through a pawl. The operating contacts consist of a platinum rod dipping into a mercury pool and can also wind auxiliary clocks by placing their electromagnets in series with the first clock, no contacts being required for the secondary clocks. Several alternative schemes are suggested.

2.9.1876 3462 Brewer,E.G. (Facic,E.E.S.) — Fanciful scheme for lighting clocks and watches by connecting an electrical pile through the wearer's watch chain to a Geisler tube (an evacuated glass tube containing traces of gases to fluoresce when a current of electricity passes through to ionise the gases). Provisional protection only.

ELECTRIC HOROLOGY PATENTS

28.9.1876 3785 Pritchett, G.E.	Method of synchronising secondary clocks by forced correction of clocks having a slight gaining rate or losing rate at intervals, together with the sounding of bells at the moment of synchronisation, also methods of sounding bells electrically.
11.10.1976 4156 Tylor,A.& Tylor,J.J.	An electric chronograph to measure the velocity of an impulse travelling in a fluid. It consists of a steel cylinder with a smoked surface turned at a known rate by clockwork. The fluid is in a tube with seated valves lifted by the impulse and open contacts which interrupt a stream of electric sparks passing from two pointers to the cylinder, these pointers are driven by a screw from the cylinder so that the distance between the cessation of the sparks may be noted and the time ascertained.
24.4.1877 Hancock, J.W.J. and Yeates,S.M. 1598	A watchman's clock fitted with a cam on the arbor of a clock which sounds an alarm if the watchman on duty does not complete an electrical circuit at the appointed time. One such clock can control several stations by fitting several cams and the electromagnet can operate a pencil or pricker to mark a paper tape to show the times when the watchman closed the circuits.
28.6.1877 2505 Eade,F & Blake, J.W.	Plating of keys etc., by double or single plating the outer edges, also gold-plating the outer edges of keys. Granted provisional protection only.
16.7.1877 2720 Lund,G.	Method of synchronizing turret clocks and other large clocks by an electrical current releasing a weighted lever acting on a lazy-tong arrangement which sets a lever on the minute hand arbor to set the minute hand to time. A cam beginning to act about five minutes after the hour raises the lever which eventually is held by the electromagnet armature detent.
20.11.1877 4349 Wrigley, A.	An electrically driven pendulum driving clockwork, a contact below the pendulum being operated by a swinging pallet when the amplitude of oscillation drops to one degree. (The Hipp toggle principle once again).
17.12.1877 4799 Brockie, J.	Electrically synchronized clocks by the action of an "S" shaped cam or straight bar acts on two pins on the back of the minute hand. An electromagnet rotates the cam or bar through an angle of ninety degrees when a correction signal is transmitted, setting the hands to time.
25.1.1878 333 Ritchie,F.J.	Control of a timekeeper by giving it a slightly gaining rate and arresting the escape wheel shortly before the hour by an electrical signal and releasing the escapement exactly on the hour. The pendulum swings freely in the meantime and resumes its impulsing when the scape wheel is free to turn again.
20.4.1878 1587 Pulvermacher, I.L.	Further details of Specification No. 3469 of September 1877 but which is not listed in the Class 139 Abridgements of Specifications or Appendices for some reason. A galvonmeter balance fitted with a pendulum is fitted with a light silk thread connection to the end of a pivoted bar. The bar is of insulated material wound with platinum wire to act as a variable resistance when lowered into a mercury trough. Actuating solenoids are mounted above the pendulum and galvonometer balance. Provisional protection only.
8.5.1878 1840 Lund, G.	Clocks set to time each hour by an open "V" notched lever acting on a pin on the minute wheel by means of a spring. Another pin on the minute wheel is held by the action of an electromagnet just before the hour and is released at the same time as the "V" notched lever is released. A series of pins on the minute wheel raises the notched lever slowly in readiness for the next operation.

ELECTRICAL HOROLOGY PATENTS

* 1878

17.5.1878
1988
La Cour, P.

A magnetised reed or tuning fork is fitted with a set of electrical contacts and maintained in vibration by two electromagnets attracting the tines, adjustable weights on the tines regulating the frequency. The intermittent currents are fed to a "phonic" wheel consisting of a toothed wheel of iron having a pole of an electromagnet in close proximity to one tooth. Once set in motion the wheel continues to rotate in synchronism with the frequency of the fork, a cylinder containing mercury is fixed below the wheel and rotates with it, evidently to assist the starting of the wheel. A cylinder fitted with anchors may be used instead of the phonic wheel.

21.5.1878
2029
Muirhead, R.K.

Electrical synchronization of clocks by a "V" notched lever acting on a pin on the back of the minute hand at the end of each hour. Alternatively the hand may carry the "V" notch and be acted on by a pin. An electromagnet actuates the lever on receiving a current from the master clock.

20.6.1878
2467
Shepherd, C.

A master clock is fitted with a set of contacts to transmit alternate reversed currents from two batteries in separate circuits controlling clocks. Two bar magnets are mounted in an astatic mode on a vertical axis, the lower magnet of which is surrounded by a solenoid and form the drive for a secondary clock, rotating synchronously with the pendulum of the master clock and driving an escape wheel via a pin or a bevel gear, thus turning a clock train. With the bevel gear, the drive is suitable for a telescope.

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25.9.1878
3774
Casson, T.

A very slight application of electricity to horology, consisting of bell striking and clock winding by pistons in cylinders placed near the clock and bells. These receive a charge of coal gas and air, and a standard regulator causes a gas flame or an electric spark to ignite the charge. A spring or weight is also moved by the piston to ensure that the next gas/air charge is forced into the cylinder. Provisional protection only.

1 .10.1878
4007
Brandon, R.H. (Firmhaber, C.W.)

An omnibus patent for electric clocks. 1. Connecting distant dials to a mantel clock. One or more gold pins on the escape wheel touch an insulated silver contact to transmit pulses from a battery to a distant dial. 2. A pin moved by the striking train controls the distant clock striking. 3. Synchronization of the hands is mentioned but the description is merely that of the action of the secondary clock mechanism to turn the hands of the distant dial. 4. Rewinding of a spring to maintain the motion of the escapement of the main clock.

15.10.1878
4094
Pulvermacher, I.L.

Final application of the method described in Specifications No. 3469 of 1877 and No. 1587 of 1878. By means of two resistance blades actuated alternately by a galvanometer balance through a silk thread, immersion in a mercury bath varies a current from a maximum in a positive direction to a maximum in a negative direction to provide an alternating frequency current of one cycle per second. The actual application to secondary clocks is not mentioned.

14.12.1878
5136
Mills, B.J.B. (Ganelli, E. & Bardelli, F).

Alarm watch worked electrically. On the dial side of a watch movement is placed a spring contactworked by a projecting stud on the hour wheel, the stud riding on the edge of a ring carrying the alarm hand. At the appropriate time the stud enters a notch and the spring contact touches another but insulated contact below the dial plate, completing an electric circuit and sounding an alarm. Provisional protection only.

ELECTRICAL HOROLOGY PATENTS

1879	9.7.1879 Port, H. & Varley, T. 2795	This is essentially a gravity arm drive to a pendulum, an electromagnet being used to reset the gravity arm. The duration of the impulse to the pendulum is set by what is described as an impulse meter, two stops being fitted so that the duration of the impulse can be adjusted and an impulse may be given every ten or twenty swings of the pendulum. The main pendulum operates contacts which control an indicator clock and other secondary clocks as required.
	13.7.1879 3259 Neale, M.T.	A series of time indicators are kept in exact time by means of an electrical circuit closed every minute. At each closure a relay needle is deflected at the local clock and a local battery is brought into action. The minute hand arbor of the master clock has sixty teeth and a roller to give the necessary impulses.
1880	3.1.1880 303 Morgan-Brown, W. (Bliss, G.H.)	Synchronizing clocks for telephones. A disc on the seconds hand arbor carries a pin which at the zero position engages a catch, stopping the clock until a synchronizing signal from the central clock energises an electromagnet which releases the seconds arbor and the clock resumes its going.
	12.7.1880 2865 Lund, J.A.	Synchronizing clocks with errors up to thirty minutes by an electric time signal from a standard clock. To any convenient wheel in the motion work is fixed a heart-shaped cam set by a weighted lever when the time signal occurs. Provisional protection only.
	13.7.1880 2891 Lund, J.A.	Means of testing telegraphic circuits for use with synchronized clocks and means of switching out defective standard clocks and connecting a substitute. A weak local testing battery and another battery to work an alarm if the signalling circuit is broken. Provisional protection only.
	9.9.1880 3648 Robertson, F.M. & Joyce, J.	A combined oil lamp and clock to which an electric alarm is fitted. One pole of the battery goes to the minute hand and touches a stud fixed at the dial for the time required, upon which an alarm bell rings. A float in the lamp reservoir may also be used.
	21.9.1880 3821 Haddan, H.J.	Basically the automatic winding of pendulum clocks by hydro-pneumatic force, the mechanism of which is connected by wire to an observatory clock and periodically controlled by an assistant making an electrical contact. Provisional protection only.
	29.11.1880 4961 Mayr, J.	A somewhat nebulous scheme for placing the signal contacts on the "hour axle" of a standard clock, better is the proposal for two single-toothed discs which can be varied in angular displacement to vary the length of a contact as required. A design is proposed for stepping the ratchet wheel in secondary clocks by two ratchets, plus of driving heavier hands. Provisional protection only.
	1.12.1880 4994 Scott, B.C.	Watchmen detector recorder incorporating a paper tape driven by clockwork stamped by the action of an electromagnet pressing a carbonised ribbon on to the paper and discs embossed with minutes and hour figures. Provisional protection was not allowed.
*	4.12.1880 5051 Thompson, W.P. (Lemoine, A.)	This is the famous "butterfly" escapement, basically a Hipp toggle maintained pendulum, but having a paper vane attached to the swinging pallet so that the air resistance causes it to be out of the vertical position until a minimum amplitude is reached, upon which a contact spring is forced down and an impulse given to a soft iron armature fixed at the end of the pendulum by an electromagnet fixed immediately below it. A pawl moves a ratchet wheel tooth by tooth at each double swing to advance the minute hand.

1881 19.3.1881 1206 Harper, R.R. — A dial or drum covered with paper is revolved by clockwork marked with hours and subdivisions, with a pricker actuated by an electromagnet to punch an impression when a signal current passes. For checking a watchman, contact keys are placed at points on his round, when the key is operated the instant of the operation is recorded.

13.4.1881 1613 Lake, W.R. (Campbell, I.T.) — Watchmen detector with a clockwork driven drum marked by an electromagnet pressing on a ribbon to mark a paper record. The drum is moved sideways so that the record can last for several days duration. An alarm is fitted, should the watchman fail to key his station at the correct time, this operates. Other safety devices are included in case of tampering or for when the watchman is off duty.

14.6.1881 2593 Clark, A.M. (Schweiser, J.) — A periodically raised weight by the action of an electromagnet drives a clock train, a small spring provides maintaining power during the brief rewinding action. As the weight rises, contacts open to de-energise the electromagnet; as the weight falls, the contacts re-close to repeat the cycle. Should the battery become too weak to raise the weight, the circuit is automatically disconnected.

25.7.1881 3247 Reid, F.T. & Valentine, J.U. — An ivory wheel fitted with contact points is driven from the third wheel of a clock and the electrical circuits completed re-wind the clock and also drive the secondary clocks through an electromagnet relay. Arrangements are made for correction and regulation of the regulator, plus means to prevent the ratchet wheel of a secondary clock advancing more than one tooth at a time, and striking.

4.8.1881 3380 Thompson, W.P. — A spring driven clock is fitted with a paper covered dial turning once a day, on which records the times when a circuit is made.

24.8.1881 3696 Shepherd, C. — Clockwork is driven or a gravity escapement actuated by the reciprocating action of a magnet in coils, or the reverse arrangement. This is combined with a shaft carrying a flywheel to cause the turning to be continuous. The method of connecting is that employed in Specification No. 2467 of 1878.

27.10.1881 4695 Barrett, W.F. — An arrangement for controlling of switches by clocks at certain times of the day or night, making use of telephone circuits for the purpose, commucications being broken for ten to thirty seconds; at night the clock circuit can be placed on an alarm or police circuit.

8.11.1881 4882 Thompson, W.P. (Lemoine, A) — The main feature is the striking of hours solely by electrical means in a clock, the pendulum of which is maintained by an electromagnet fitted under and one side of the centre of swing.

8 .11.1881 4883 Bauer, M. — Describes an electro-pneumatic system for winding clocks and correcting them by making use of a telegraphic line for about ten seconds at midnight, the line being available for normal use at all other times. The master clock is itself regulated from an observatory regulator clock.

* 23.12.1881 5638 Webster, E. & Williams, T.M. — A method of obtaining a rapid make and a rapid break from an arbor of a clock by means of two cams operating levers which drop off the cam suddenly, one slightly after the other, to first close a circuit and then open it shortly afterwards. The cams raise the levers slowly in readiness for the next switching operation.

1881	24.12.1881 5656 Brewer, E.G. (Buell, C.E.)	Describes methods for utilising telephone and telegraph lines for controlling clocks from a central clock without interrupting the normal transmissions, it depends on the fact that the clocks make use of reversals of current in operation, whilst the telegraphic and telephone instruments make use of changes in current and are unaffected by the polarity of the lines. Separate local batteries may be used for the control clock and the telephone appararatus.
1882	18.5.1882 2330 Llewellin, W.M.	Mainly in connection with tell-tale clocks but mentions that a main gate of a factory may be opened or locked electrically and automatically by a clock. Provisional protection only. Specifications No. 1554 of 1855 and No. 2472 of 1881 are quoted.
	23.5.1882 2428 Imray, J. (Knudson, A.A.)	The minute hand of a clock is fitted with a correcting bar and a Geneva detent. A cam on one of the arbors of the clock throws the the correction shaft into the operating position and a synchronizing signal operates the armature of an electromagnet in the base of the clock to adjust the minute hand.
	16.6.1882 2840 Shaw, H.S.H.	The main feature of this patent is a contact maker of a platinum wire dipping into mercury through a lever worked from the escape wheel teeth of a clock, the contact arrangement being enclosed in hydrogen gas to avoid oxidisation of the contacts. The hydrogen is trapped below a glass bell and mercury seals it from the air. The opening and closing of the contacts can be used to control clocks.
	6.7.1882 3190 Schweitzer, A. Lawrie, T.	A tell-tale clock which moves a paper tape on which a record of the hours is printed from a type wheel, the workman has his mark and by pressing the appropriate keys, this is marked on the paper tape by means of type bars operated by electromagnets.
	7.6.1882 3233 Schlaefli, J.P.A.	Description of a secondary clock which is very like the standard Synchronome slave dial movement but has a wheel geared to the ratchet wheel which bears three teeth and acts an escapement wheel to allow the stepping of the mechanism tooth by tooth. The arrangement is operated by the weight of a gravity lever, and this is raised by an electromagnet at intervals of one minute.
	27.7.1882 3572 Lake, W.R. (Wilson, R.W.)	A mechanical clock has synchronizing of the minute hand by having the minute loosely mounted on the centre arbor and driven by a friction plate and spring. At the hour an electromagent operated from a standard clock withdraws the plate, allowing a spring arm to bear on the hub of the minute wheel and turn it until a flat surface on it coincides with the spring, bringing the minute hand to the correct time.
	5.8.1882 3751 Lake, W.R. (Blodgett, G.W. & Blodgett, A.D.)	Several forms of electric gong signalling apparatus are described, one which is illustrated consists of a drum with twenty-four grooves, each having sixty holes, the drum rotating one revolution per hour. Pegs are fitted into the holes at the desired time of operation and contact an electrode, the latter is moved through the space of one groove each hour so that the whole of the twenty-four period is covered, at the end of which the electrode returns to its starting position. For Sundays a separate drum is used to cope with the Sunday timetable.
	29.8.1882 4127 Wright, T.	A circuit-closer designed to give impulses at half-minute intervals by a contact wheel turned by two ratchet wheels rotated by two electromagnets stepping them tooth by tooth. There appears to be no means of securing accurate time intervals. Also an indicator having a ratchet wheel of 120 teeth and another with slots corresponding to each twelfth tooth, enabling both minute hand and hour hand to be set from the same lever with two pawls.

1882	3.10.1882 4712 Webb, B.W. Jensen, H.P.F. Jensen, J.	Electric alarm clock, the alarm part of which can be removed from the parent clock and be operated at some distance, connecting wires being wound on a drum. A toothed wheel on the arbor of the hour hand has a pin or stud which forces an alarm pointer into a notch, an electric contact is made and sounds an electric bell. A striking device is described where every stroke can be repeated on an electbell, as well as upon the bell of the clock.
	16.10.1882 4919 Lund, J.A.	Standard and other clocks of any size can be synchronized to fractions of a second by control of the current through a coil surrounding the pendulum rod or in front of it, acting on a permanent magnet fixed above on the pendulum rod. An arrangement with two electromagnets in conjunction with pins on the seconds and minute wheel arbors alters the strength of the current by a signal from a standard regulator clock.
	28.10.1882 5136 Wetter, J. (Ransom, G.F.)	Watchmen detectors consisting of a clockwork driven drum carrying a paper disc which is perforated by needles operated by a series of electromagnets energised by pressing suitable buttons situated at the inspection site.
	31.10.1882 5182 Imray, J.	A modification whereby the arrangement of the circuits described in Specification No. 2428 of 23.5.1882 can be worked with one line instead of the former two lines necessary.
	4.11.1882 5279 Lake, W.R. (Standard Time Co. of New Haven)	To secure a rapid make and break of an electric circuit when a minute hand is used to initiate a signal at a certain time, an insulating block with an incline in the direction of the approaching hand lifts the hand slightly and at say twelve-o-clock, the hand drops off the vertical edge on to a metal lip fixed at the side of the block, contact is made and the signal sent. Shortly afterwards the minute hand drops off the metal lip to its normal plane and contact is broken; thus the make and break action is rapid.
	4.11.1882 5280 Lake, W.R. (Standard Time Co. of New Haven.)	A curious means of synchronizing electric clocks by conveying impulses through gas or air pipes. The master clock sends a signal which opens a valve momentarily to allow a pressure impulse in the pipe, At the site of the controlled clock is fitted a U-tube fitted with contacts operated by changes in the level of the mercury filling. A pressure increase closes a contact and the local clock is set to time.
1883	17.2.1883 880 McFerran, J.A.	Arrangement of secondary clocks with escapements governed by a master clock periodically, whereby one of the secondary clocks takes over the function of the master in case of its failure. The special secondary clock has a subsidiary drive to an escapement and closes contacts about three-quarters of a second after the regulator clock time if not impulsed by the master clock.
	14.3.1883 1370 Jolin, P.	A series of proposals for measuring the amount of electric current through a meter but with applications to electric clocks, mainly involving the use of solenoids and electromagnets.
	22.3.1883 1523 Lund, J.A.	Improvements to Specification No. 3924 of 1876, the well known Lund correction of the minute hand at each hour. it is merely a rack and pinions to work the setting pins by a rod from the armature of the electromagnet. Provisional protection only.
	20.7.1883 3578 Harrison, W.S.	Detailed account of a clockwork mechanism setting a spring for synchronizing the minute hand of a clock which is unlocked by an electric signal. Utilisation of telegraph lines and the synchronising of seconds hands is covered, plus recording of the cumulative error of the governed clock.

ELECTRICAL HOROLOGY PATENTS

1883	1.3.1883 3763 Heriotizky, G.M.	An electrically driven master clock in which the pendulum which at each oscillation moves a seconds wheel (half-second pendulum) Every minute a contact is made by a lever on the seconds hand arbor with a bell-cranked lever and the pendulum completes the action, upon which an electromagnet is energised, lifting a lever which is held until the pendulum returns, when a pin releases the lever and an impulse is given to the pendulum to maintain its motion. This lever also advances a minute wheel step by step, it bears four projections so that the clock may strike an electric bell at every hour or quarter as required.	
	27.9.1883 4609 Thompson, W.P. (Winbauer, A.)	An electric clock rewound by the action of a weighted lever being thrown up every few minutes, the weighted lever acting on the minute wheel arbor to drive the clock train. A spiral spring in a barrel serves to act as a maintaining power when the lever is raised by means of an electromagnet armature. This method is adopted to secure constant rate of the clock regardless of the state of the battery as long as it can replace the weight.	
	23.10.1883 5025 Fletcher, J.W.	A recording clock of any suitable type is connected to an electrical circuit. At each station is a device with an armature held in place when a key is inserted, a permanent magnet being employed. On reaching the recording clock for the last visit, the first operation causes a record to be made, the second sends a current to oppose the field of the magnets and the circuit is reset for the next set of visits.	
	23.10.1883 5047 Gardner, W.F.	Relates to a system which can set the hour, minute and seconds hands of clocks in a circuit to an unlimited extent. It consists of a standard mean time clock, a primary transmitting or control clock, a series of secondary clocks. Each secondary clock has its own driven train and is independent should the system fail. Signals are sent out to perform all the required corrections.	
	30.10.1883 5153 Schisgall, S.	Making use of a half-seconds pendulum, a seconds wheel is rotated by a spring at the top of the pendulum moving a ratchet wheel and so arranged that an electrical contact is made when the pendulum swings slightly to the left, an electromagnet attracts a lever which gives the pendulum an impulse and turns the seconds wheel. A pin on the latter turns the minute wheel. A commutator on the seconds arbor reverses the current from two batteries alternately for fifteen seconds each to increase the duration of going.	
	21.11.1883 5475 Allison, H.J. (Wilson, R.W.)	Using a separate train to provide the power to synchronize a controlled clock so that the control signal is reduced in amount by not having to do the work directly. Any suitable controlling impulse may be employed.	
	24.12.1883 5851 Brandon, R.H. (Kettell, J.F.)	Another scheme for utilising the lines to controlled clocks for telephonic or telegraphic purposes except when required to control the clocks for a few seconds at every hour. The clocks employed appear to be spring driven.	
	28.12.1883 5885 Brookes, A.G. (Downs, L.N.)	This describes a scheme to provide subscribers to a telephone system by the correct time from a single clock by signals sent in succession throughout the day. Audible signals are sent, in three groups. for example 3.59 would be 111, 11111, 111111111. How zero is transmitted is not explained. The scheme does not prevent telephonic communication since subscribers who are talking to each other are disconnected from the time service.	

ELECTRICAL HOROLOGY PATENTS

1884	18.1.1884 1681 Mills, E.J.B. (Diener, C. & Mayrhofer, C.A)	Relates to a scheme whereby a regulator clock closes contacts and the current in the circuit is used to control a water supply which compresses air for winding and setting clocks. A safety device is fitted to prevent water getting into the air supply and to prevent damage should the water pressure be too great.
	24.1.1884 2036 Moore, G.	Consists of a cam revolving once in forty-eight hours driven by a clock. The cam oscillates levers to make contacts operate at the required time and an electric bell sounds. Switching the alarm off resets the alarm in readiness for the next day.
	14.3.1884 4874 Colton, E.G. (Kiek Bros.)	A ratchet-wheel with hooked teeth is used in secondary clocks worked by the armature of an electromagnet, on which a hooked spring is fixed to ensure that only one tooth is operated at a time. Another lever and pawl prevent any reverse motion.
	27.8.1884 11,709 Calliphronas, T.	Two electromagnets reciprocate a swinging armature and raise gravity arms whilst changing over contacts to energise the electromagnets alternately. The pendulum rod is part of the circuit, so when the gravity arm is left by the pendulum rod, current ceases to flow. Two separate batteries are used, and the armature also turns an escape wheel through driving and stop pawls.
	5.9.1884 12,021 Eshelby, J.	A transmitter clock is provided with two contact-makers completing their circuits at short intervals and once an hour. This controls distant striking mechanisms, each fitted with a count-wheel having 12 pins and 102 teeth. An electromagnet moves the wheel forward one tooth each time the contact is broken, when the count-wheel is at rest, one pin holds the contacts apart until another contact maker is moved by a control signal and the count-wheel moves forward one tooth and the bell is struck until another pin breaks the contacts again when the correct number of strokes have been made.
	5.9.1884 12,026 Knight, J.G.	Comprises a crutch on which is mounted a soft-iron armature and a pawl turning a ratchet wheel, the latter closing contacts periodically to energise the electromagnet which attracts the armature and impulses the pendulum. The clock train turns a cam once in twenty-four hours to switch in one battery and switch out the old.
*	8.9.1884 12,153 Boult, A.J. (Rabe, G.)	This constitutes a development of the Harder patent (2182 of 1882) and applies electrical working to the torsion pendulum. A Hipp type toggle is fitted to the pendulum suspension wire and acts when the amplitude falls to the minimum amount, a platinum wire and mercury in a small vessel form the contacts. The pendulum rod carries a pawl which turns a ratchet-wheel driving the clock.
	28.10.1884 14,267 Gardner, W.F.	A controlled circuit in a main circuit is provided with a relay for acting as a control to a subsidiary system, each time the relay sets the clock to time it also sends a synchronizing signal to the remainder of the local clocks.
	15.11.1884 15,069 Trotter, A.P.	Remontoir mechanism for driving electric quantity meters. A tumble weight drives the clockwork, when it runs down an electromagnet is operated by contacts and the weight reset. In case of stoppage, a self-acting apparatus calls attention to the fact.
*	25.11.1884 15,500 Thompson, W.P. (Pond, C.H.)	Rewinding of spring-driven clocks at intervals using small electric motors having rotors with soft-iron bars attracted by electromagnets, a pawl being fitted to prevent reverse rotation. When the current is not being used for rewinding, it may be used to synchronize the clocks by means of an electromagnet acting on an armature mounted on the pendulum. For winding these synchronizing circuits have to be shunted to prevent maloperation.

ELECTRICAL HOROLOGY PATENTS

1884	2.12.1884 15,889 Thompson, W.P. (Pond, C.H. et al.)	A central regulator has a pendulum whose suspension carries a cross-bar having two contact edges touching spring mounted contacts alternately. These springs are raised by two armatures and released in turn to give impulse to the pendulum. Arrangements are made to close circuits every minute to drive secondary clocks, with a correction signal every hour. Pendulums can be synchronized with the master pendulum.
	18.12.1884 16.632 Burmann, I.	Mounted in a watch stand is a battery and electric bell to form an alarm system. A watch fitted with a turning bezel insulated from the watch case carries a pointer which is set to the appointed time. Either a small spring is fitted to the hour hand or the alarm pointer to complete the circuit as required by one touching the other, the period of the alarm being governed by the width of the spring. The watch may be arranged to ring a distant alarm also.
1885	2.2.1885 1439 Rixon, A.W. Theiler, R.	An ordinary clock less the spring or weight drive is driven by a stretched spiral spring initially tensioned by an armature being attracted to an electromagnet, a pawl turning a ratchet wheel on the driving wheel to allow winding to take place in the reverse direction.
*	24.2.1885 2509 Aron, H.	Electromagnetically maintained pendulum with a crutch bearing a gathering pallet to turn a ratchet wheel, and a pin to impulse the pendulum. An armature attached to the crutch is attracted to the electromagnet when the appropriate contacts are made by the pawl lever, all the operating parts are provided with india-rubber to reduce the noise, whilst the electromagnets are wound with alternate layers of wire and metal foil to reduce sparking at the electrical contacts.
	14.4.1885 6529 Thompson, W.P. (Baumann, F.)	Electrically rewound remontoir spring which drives a going train and the minute wheel of the clock winds another spring to drive the striking train. An electromagnet attracts a soft-iron armature to drive a ratchet wheel for the rewinding action. (Note that the serial number of this patent is out of chronological sequence).
	19.5.1885 6116 Jensen, H.P.F. Webb, B.W. Jensen, J.	For domestic use a clock is fitted in series with an alarm system and a switch in the bed completes the circuit when it is occupied. On sounding, the alarm sounds until the person rises from the bed and breaks the circuit. It is recommended that the cancellation switch preferably be placed in a separate room to ensure wakefulness!
*	20.6.1885 7584 Pond, C.H.	Synchronization of electrically rewound clocks by a regulator clock closing a circuit which excites an electromagnet at each clock and switches on an electric motor and brings the parts of the synchronizing mechanism into position to be acted upon by the winding mechanism to set the minute hand. When synchronization is completed, the electromagnet is shunted. (The basis of the Self Winding Clock system so widely used in America).
	29.6.1885 7881 Clark, A.M. (Wirth & Co. acting for Sauer, A.)	The master clock in this system is a Hipp toggle type arrangement to drive the pendulum, in the slave clock there is a swinging armature attracted by an electromagnet, this is coupled to a pawl and ratchet wheel. A safety detent is also fitted to the armature to prevent mal-operation. The clock is built like a piece of laboratory equipment and has an imitation compensated pendulum.
	1.7.1885 8011 Harrington, J.	Any form of chiming apparatus is fitted with an electromagnet to attract the detent from the locking plate, upon receipt of an electric current from a clock. A pin on the same detent releases an arm on a wheel arbor carrying the fly, this allows the train to start.

1885	14.7.1885 8538 Plancke, D. van de.	Description of an indicator clock, the main feature of which is a cam to operate contacts so that current is cut off through the electromagnet as soon as the action is completed. The armature carries a lever which turns a flywheel through one revolution and then locks it, the resulting motion being used to wind the indicator clock, alternatively to drive a minute wheel arbor by means of a worm.
	20.7.1885 8727 Justice, P.M. (Heyssinger, I.W. and Pusey, J.)	Incandescent electric lamps applied to the hands and numerals of a public clock. At night an inner set of numerals formed by metal filaments inside vacuum tubes are lit by the passage of electric current, together with lamps on the hour and minute hands. An independent current may be used for the filaments of the lamps on the hands, regulated by a switch.
	27.7.1885 9028 Binter, G.	Automatic recording of temperatures by printing or pricking of a paper tape, the tape being advanced by a clockwork drive. Each time the marker operates it advances a cylinder carrying the paper by a ratchet wheel in order that a record may be made by thermometers whose mercury columns complete the circuit at 5°, 10°, 15°, and so on. By this means the maximum temperature may be continuously monitored.
	6.10.1885 11,898 Thompson, W.P. (Clarke, C.L.)	Mainly concerned with the remote indication of pressure gauges, thermometers, etc, use being made of relays to avoid damage to delicate contacts and to allow circuits with heavy currents to be controlled by weak control signals, current interruption being arranged to take place in separate circuits which open after the sequence is complete, and providing means of indication of failure of any instrument. The latter uses an electromagnet whose armature is controlled by a dashpot and does not respond to short pulses. A modified version may be used to control a series of clocks.
	6.11.1885 13,453 Colton, E.G. (Haenichen, F. Haenichen, O. Seebass, O.)	Maintaining system for a pendulum in which reverse currents are passed through two electromagnets, each armature being retained in position by the residual magnetism until the current is reversed and suddenly broken, releasing a crutch and impulsing the pendulum. A bar at the top of the pendulum carries contacts for the switching arrangements. A pawl attached to an extension of the armature drives the clock train in the usual way.
1886	27.1.1886 1220 Cassey, J. Dixon, J.F.	Contacts suitable for use with clocks which may be of any suitable form, make rubbing contact in paraffin or other non-conducting liquid to prevent corrosion. Steel and silver are preferred, and the circuit arranged so that current passes from the smaller contact into the larger contact.
	2.2.1886 1550 Frost, R.	Any form of alarm clock may be used to complete an electric circuit which includes an electric bell. The example given is the ordinary alarm fitted with a snail cam where a contact is made at the set time to ring the bell. A brass plug fitting into two brass blocks may be pulled out to silence the electric bell.
*	9.3.1886 Millard, G.W. Clarke, J.H.	Means by which periodic currents from a master clock can be made to regulate the rate of secondary clocks, each of which has a slider rotating over segmental contacts, and according to the control circuit thus switched in at the time of regulation, the pendulum is raised or lowered at the suspension spring between two cheeks or a small weight on the pendulum rod is screwed up or down. For balance wheel clocks, the balance spring is adjusted through its regulator arm.
	15.3.1886 3655 Beck, W.H. (Naudin, L.S. Naudin, P.F.)	Watchmen detector worked by electromagnets to mark the paper revolving drum worked by clockwork to show the hours and days of the week, an ordinary clock dial also being fitted on the instrument. It was known as "Naudin's Auto-Monograph".

ELECTRICAL HOROLOGY PATENTS

3.5.1886 646 nright, J.	Apparatus attached to a clock for closing electric circuits at specified times. Supplementary wheels are attached to the clock, one turns in twenty-four hours, the others in one hour and five minutes respectively. The last wheel has eight sinucus shaped teeth to generate intermittent currents and is not required if continuous currents only are necessary. Thus drainage can be flushed, bell, alarms, signals may be actuated, or gas and water valves controlled.
7.5.1886 146 oehring, W.	Watchmen detectors operated by electromagnetic marking of a paper record when a circuit is interrupted. The "Writing wheel" is turned by a second clockwork mechanism and prints "Morse" signs to identify the station which has been keyed.
1.6.1886 181 orrain, J.G.	Alternately reversed currents are generated by a master clock and are transmitted to secondary clocks which have driving motors with curved pole pieces for the field, the armature consisting of a permanent magnet of similar shape and rotated through 180° by every reversal of current. The motor arbor carries a worm to turn the minute hand arbor, a spring presses on one of two flats on the motor arbor to prevent reversal and acts as a brake. The design and construction suggested lead to a very compact and simple clock.
.7.1886 751 orrain, J.G.	Winding of a clock by alternately reversed currents to pass through an electromagnet which rocks a permanent magnet armature or electromagnet armature to drive a ratchet wheel through a pawl. A spindle driven from the clock train carries two discs for current reversals.
.7.1886 896 orrain, J.G.	Similar to the preceding specification but the armature rotates only half a turn for each reversal of current. A worm on the armature arbor drives the winding arbor of the clock and the clock train operates a current reverser to energise the electromagnet. (These three preceding specifications would have been better incorporated into one, it would have saved money,time and effort).
9.7.1886 365 avey, H.	An arbor is driven by a water-wheel, weight or spring, carries two arms with rollers that alternately raise the horizontal arm of a bell crank gravity pallet, the vertical arm of which gives an impulse to the pendulum through a roller. The horizontal arm carries a pawl to turn an arbor once every minute, a stud on its wheel then makes and breaks a current once a minute to control clocks.
.8.1886 986 amel, A. & ean, W.W.	Hourly synchronizing of the minute hands of secondary clocks by two cranks turned by two wheels through one revolution by a spring driving a train. An electromagnet armature controls these actions on receipt of a control signal from a master clock.
9.7.1886 1,194 avey, H.	The same scheme as Specification No. 9365 of 19.7.1886, modified so that the water-wheel, weight or spring is not required, the gravity arm and pallet being raised by the attraction of an electromagnet armature.
.9.1886 1,317 addan, H.J. arnes, C.M. & aker, N.E.	Mechanism driven by a clock whereby electric bells are rung in any room of a house, or parts of a ship, etc. Through suitable gearing the clock drives a metal disc pierced with several concentric circles of holes, each circle corresponds to a room, each hole is at quarter hour intervals. A peg is placed in the hole corresponding to the time and room to be called. In case of fire, all the bells are connected in parallel and simultaneously sounded.
1.9.1886 1,990 ornmuller, .J.	Electromagnetically operated vibrating drive to a ratchet wheel to actuate clocks, the main advantage being a prolonged impulse and increase of amplitude of vibration. Two armatures are used, the smaller being held to prolong the period of contact by a permanent magnet until pulled off by a bridge on the main armature

ELECTRICAL HOROLOGY PATENTS

1886	25.9.1886 12,222 Rudd, R.J.	Mechanism for driving a clock by a counter-weighted lever bearing a rack meshing with a pinion to drive the escapement of a standard clock fitted with a pendulum. When the rack descends to a contact, the electromagnet attracts an armature until a vertical rod extension pushed by the armature breaks a pair of contacts and the armature returns. The breaking of the contacts switches off the current through the electromagnet, another pair of contacts makes a circuit incorporating secondary clocks. A pawl attached to the armature may be used to turn discs to indicate hours, minutes, and and seconds; or time day and month.
	1.10.1886 12,491 Reclus, V.	Rewinding of electric clocks by electromotors at the standard and other clocks, the clock springs being wound automatically, the driving armature rewinding on both up and down strokes.
	8.10.1886 12,840 Hoefling, C.F.	Synchronizing of a secondary clock at the hour by a standard clock transmitting a signal. At the secondary clock an electromagnet armature behind the dial pulls down a pin causing two arms to come together against a pin placed on the rear of the minute hand. The operating pin then passes past the tails of the two levers to make certain the synchronizing levers do not impede the minute hand once correction is completed.
*	17.11.1886 14,395 Davey, H.	An unusual design where the pendulum itself carries a thirty teeth count wheel turned once a minute by a lever with a pawl catching a against a stop. On the countwheel is a pin which comes opposite a projection on a long vertical lever and moves it to operate electrical contacts, thus arming an electromagnet whose armature carries a long flexible spring to give impulse to the pendulum. The lever carrying the armature operates a bell crank moving a pawl feeding a sixty-toothed ratchet wheel at one tooth per minute, every twelfth tooth recess is made deeper so that the pawl also moves the hour wheel one tooth every twelve minutes, ie the hour wheel moves through five teeth per hour of a sixty toothed wheel. For synchronization at the hour, an electromagnet lifts the pawls of the minute and hour wheels and then advances two levers bearing on two heart-shaped cams mounted on the arbors of the hour and minute hands.
	9.12.1886 16,141 Tozeland, J.R. Tozeland, H.F.	"Portable clock" with a case that encloses two wet Leclanche cells, a pendulum clock, and an electric bell. The clock is weight driven and so arranged that the weight runs over a scale marked 0-12 upwards and it is lifted by hand to the number of hours to pass before the alarm is required to act; i.e. placed at six on the scale the alarm sounds six hours later. The weight reaching 0 on the scale, depresses a lever and thus operates a switch. The alarm rings until the weight is lifted.
	18.12.1886 16,650 Skrivan, O. & Dvorak, F.	Watchmen detector employing four stations visited once every quarter hour, the central station being informed of the visit by a bell ringing. Indicators driven by a contained mechanism show whether the watchman visited the station at the correct time, or early or late, the mechanism being driven by an electromagnet arrangement. (An early Big Brother invention).
1887	13.1.1887 567 Harrington, J.	Chiming apparatus in which the minute hand completes an electrical circuit each quarter hour by touching one of four contacts on the dial, causing an electromagnet to bring contacts into action which are operated by the pendulum at every swing to step a ratchet wheel carrying contacts, actuating a circuit to sound the hours on a bell or chime. On completion of the quarter the circuit is broken. and a stud half between the quarters on the dial resets the whole mechanism ready to sound the next quarter. A total of about sixty contacts are necessary for this alone.

ELECTRICAL HOROLOGY PATENTS

1887	1.2.1887 1609 Barnsdale, W.J.	Electrical winding mechanism in which the clock is rewound by a rotary electromotor of the usual construction, the circuit being closed at regular intervals by an arm on the driving arbor of the clock which carries the spring. The circuit is broken again after the spring wound arbor has been turned through one revolution. The spring for the striking train may be similarly rewound, a clutch arrangement allows one electromotor to wind both trains alternately.
	1.3.1887 3149 Johnson, J.H. (Rogers, J.H.)	Means of synchronizing two or more electromotors, particularly for printing telegraphs, but also applicable to electric clocks. Principally it consists of a centrifugal governor fitted with a centrifugal governor operating contacts and an armature operated once each revolution by an arm on the governor shaft touching a contact. A mirror fixed to the armature gives a visual signal, from which the observer can tell if his motor is at the correct speed, or fast slow, and thus adjust for isochronism. A spark from an induction coil may be used in place of the mirror and lamp.
	15.3.1887 3878 Boardman, H.	Alarm system consisting of a clock fitted with a rotary switch to ring any number of bells in any number of circuits at set times. The hour hand arbor carries a contact arm travelling over a series of studs, a ratchet wheel with teeth at right angles being employed to cause a stepping motion whereby the arm is lifted from one set of studs and lowered on to the next set, to disconnect and re-connect, a spring applying pressure to the arm to ensure positive contact.
	18.3.1887 4135 Haight, H.J.	Escapement for use with recording clocks where the roll of paper is advanced under the control of an escapement wheel having two concentric rows of triangular teeth on the face. A pallet of similar triangular form is attached to the armature of an electromagnet and moved when a control signal steps the escapement wheel round one tooth at a time.
	18.3.1887 4135A Haight, H.J.	Verifying indicator system. A step by step ratchet wheel is fitted to a transmitting master clock and actuated by the minute hand contacting a pin on the insulated ratchet wheel, causing it to be stepped round one tooth by an electromagnet, upon which the main circuit is closed and operates a verifying indicator near the clock. Each secondary clock is fitted with a similar arrangement.
	12.4.1887 5328 Purcelle, A.L.	Resilient rod pendulum bending throughout its length with the intention of moving the bob in an approximately cycloidal arc. The pendulum bob bob may be solid or hollow with a filling of mercury, sand or shot. A switch block mounted near the top of the pendulum is moved by the rod to operate switch brushes. An armature fixed to the end of the pendulum can be attracted by one of two electromagnets alternately, each being slightly displaced from the position of rest, and energised through the brush contact as required. A pivoted arm moved by the pendulum rod carries two pawls to advance a ratchet wheel driving the clock train. It is stated that only one brush switch and electromagnet can be used if required.
	22.4.1887 5862 Blenheim, W.	System consisting of a series of indicating clocks driven by a dynamo, the armature of which is driven by a powerful weight or spring driven train which is released at regular intervals by a standard clock train through the action of a cam. The indicating clocks are stated to be of the usual pattern. Other types of secondary clock mechanisms are described, pawl and ratchet, a magnetic needle in a coil and mounted on the seconds arbor. This system foreshadows the Magneta system.

1887	11.5.1887 7115 Humbert, C.	Illuminated watch or clock dial fitted with a dial of ground glass illuminated by a small incandescent lamp fitted with suitable reflectors. The lamp circuit is completed through a small cable fitted with a horseshoe shaped interrupter to operate as required.
	21.5.1887 7431 Boult, A.J. (Engelhardt, M.)	Pendulum working in a crutch moving a ratchet wheel fitted with a pin to complete an electrical circuit once a minute or half-minute. An electromagnet attracts an armature freeing a detent on a spring or weight-loaded lever which then gives impulse to the pendulum to maintain its motion. A centre wheel of sixty teeth is propelled by the armature on attraction and this drives the minute wheel etc. In another arrangement a pawl working over a notched block is used for the contact arrangement (Hipp toggle again). A further contact to close the circuit for the secondary clocks is actuated by the armature on closing.
	29.6.1887 9264 Lorrain, J.G.	Driving motor for clock hands with coils for the field and armature receiving impulses lasting a few seconds from a master clock at half-minute intervals. A spring detent and a pin ensure correct operation at all times.
	4.8.1887 10,742 Duboulet, H.	Clock or watch wound by an oscillating electromotor through a pawl and ratchet wheel. Operation in one case is at every hour by a pin on the minute wheel arbor; or more exactly by a star wheel rotated by a tooth on the hour wheel arbor, it is made alternately of copper and bone to open and close the electromagnet circuit. Another single tooth on the spring barrel turns the star when the spring has been wound, thus shutting off the current to the electromagnet. No mention is made as to where the battery is kept for a watch.
	5.8.1887 10,785 Lorrain, J.G.	Winding motor for clocks consisting of a commutator direct current motor turning through one half revolution per impulse from the master clock, or from its own clock. A worm on the motor spindle drives a worm wheel on the spring or weight driven arbor.
	16.8.1887 11,191 Steinheuer, H. Steinheuer, J. Rabe, H. & Rabe, E.	Winding mechanism for a clock fitted with a rotary or torsion pendulum. The clockwork when almost run down closes a circuit and the spring or weight is rewound by one swing of an electromagnet armature to drive the clock through a segmental rack. Another form uses a cord attached to the armature and it is connected to a drum driving the escapement wheel by a ratchet and pawl. (The Hanauer Electrische Uhrenfabrik, Steinheuer and Rabe).
	2.9.1887 11,938 Lorrain, J.G.	A pendulum is used as a reciprocating motor and advances the winding arbor of a clock through a pawl and ratchet wheel, being released periodically from a raised position by a detent and reset by an electromagnet attracting an armature and resetting the pendulum on its detent. A balance-wheel may be used in lieu of the pendulum. An interrupter operates the detent but its operation is not explained in the abridgement.
	27.9.1887 13,091 Viau, M.	Winding electromotor connected to the train of a clock by a Huyghen's endless or similar drive mechanism. An electric bell type of mechanism drives a ratchet wheel through a pawl. All parts are fitted with india-rubber to deaden the sound of operation. A contact on one of the arbors of the clock sets the arrangement in motion and the ratchet wheel is driven through two revolutions every five minutes or other set period as necessary.
	15.11.1887 15,660 Thomas, A.J.	Currents are sent periodically to a clock which causes an electromagnet to attract an armature to rewind a clock spring, or a cam on the clock itself can switch the current independently through the closing of electrical contacts. The same arrangement may be used to work hands over the dial.

ELECTRIC HOROLOGY PATENTS

1887	21.11.1887 15,993 Thompson, W.P. (Harford, A.B.)	Dial fitted with contacts at hour intervals, the latter are connected to a busbar system of electric bell circuits installed in hotel rooms. By the insertion of plugs, the clock may ring a bell in any room but only on the hour, at other times the pressing of a key sounds the bell. By placing all the bells in action simultaneously, the system may be switched as a fire alarm also.
	1.12.1887 16,538 Kelso, M.G. & Reichert, G.	Watchmen detector designed to show the time when premises are opened for business, or closed, or inspected. Contact springs attached the entrance door open and close the circuit, actuating a marking mechanism to mark a paper strip controlled by clockwork through the medium of an inked roller. A period of a week is covered at a time.
1888	18.1.1888 804 Pulvermann, M. (Bohmeyer, C.)	Secondary clock with an electromagnet whose cores are subjected to the magnetic field of a permanent magnet, oscillating a pivoted polarised armature when alternate reversed currents are passed through it from a master clock, driving a ratchet wheel by means of two pawls which are alternately jammed under a pin after progressing a tooth, thus locking the wheel at all times except during the progression itself.
	31.1.1888 1406 Turton, M. & Turton, S.	An ordinary alarm clock is mounted on the lid of a case containing a wet Leclanche cell and an electric bell. The lever actuating the mechanical alarm is arranged to touch an electrical contact and at the set time the electric bell sounds. The ordinary alarm need not be wound, and a silencing switch is fitted to turn the bell off.
	28.2.1888 2998 Harrison, W.S.	An improvement on the mechanism described in Specification No. 3578 of 1883 which is a spring driven mechanism to correct the minute hand of a clock on receipt of a signal from a master clock.
	1.5.1888 6459 Lake, H.H.	Another arrangement to record the activities of nightwatchmen on a paper wrapped on a time drum by marking it on the receipt of electric signals from the stations to be visited.
*	3.5.1888 6614 Craven, E.G.	Illumination of a clock dial by an electric lamp switched on and off at intervals during the night, and entirely during the day by a revolving switch which may be a spring on a wheel touching a fixed contact point, or by means of a mercury switch consisting of a glass tube containing a little mercury to bridge two contacts projecting into the tube when the tube is tilted towards the contacts.
	12.6.1888 8637 Parcelle, A.L.	A flexible strip pendulum rod designed to produce approximate isochronism of the pendulum bob, is maintained either by an electromagnet directly or through a spring, the latter method giving a constant impulse regardless of battery voltage. A pendant switch is operated by the pendulum rod and oscillates over a contact brush, the centre contact energises the electromagnet, the outer ones short the battery, for what reason is not stated. The pendulumm drives a ratchet wheel by means of an arm with a driving pawl.
	31.7.1888 11,106 Lake, H.H. (Davis, E. & Welch, E.B.)	Apparatus applicable for fire, police, or other calls or checking night watchmen. A spring contact piece is drawn over stud contacts on a dial to give a "Morse" signal which is registered on a Morse recorder. A warded key ensures that each user may give his distinctive signal only.
	28.8.1888 12,396 Thompson, W.P. (Edgecomb, D.W.)	An amendment to ensure that a rotary armature may not, after stopping, be left at a dead point in the action: the teeth or lugs against which the recoil checking pawl acts are separated by large angles. (Amendment to the drawings accompanying the specification).

1888	24.11.1888 17,123 Mayrhofer, C.A.	Synchronizing apparatus for secondary clocks using the conductors of a telephone or telegraph system. The contolled clocks have a notched wheel to break the telephone system circuit and connect an electromagnet operating a synchronizing lever when a contact is made at the master clock, after whic the telephone line is reconnected.
	1.12.1888 17,535 Davis, L.M.	Swing spirit lamp combined with electrically operated apparatus for domestic use, an incandescent lamp and an alarm operated electrically in case of fire. In the same case is a clock controller.
*	31.12.1888 19,066 Lorrain, J.G.	To operate secondary clocks use is made of the expansion and contraction when current is first passed through a wire and then cut off. The wire thus moves a pawl stepping a ratchet wheel, advancing the clock hands in step with a signal sent from a master clock. Minor interruptions of current do not affect the action.
*	31.12.1888 19,067 Lorrain, J.G.	Secondary clock employing a glass tube pivoted at the middle and having an upturned glass bulb at each end, partly filled with mercury to give an air space in each bulb. One of the bulbs contains an heating coil and is normally below the level of the other bulb, when a current is passed through the coil the mercury is displaced into the higher bulb and it descends. The resulting motion then drives a ratchet wheel through a driving pawl to operate the hands. Banking screws limit the arc of movement of the glass tube.
*	31.12.1888 19,068 Lorrain, J.G.	Winding mechanism depending upon the expansion of a long wire conductor supporting a weight, the lever holding this weight descends when current is passed, only to rise again as it cools when the current ceases. The lever drives a ratchet wheel to wind the spring arbor of the clock, the movement is limited by banking pins.
	31.12.1888 19,069	Air is expanded in a vessel repeatedly by an electric current, the increasing pressure moves a diaphragm actuating a ratchet wheel to wind up a weight or spring to drive a clock. Contacts switch off the current after each movement to allow the air to contract again. (Note: These four preceding patents could have been embodied in one since the principle involved is the heating effect of a current).
1889	19.1.1889 983 Adams-Randall, C.	Electrical mechanism controlled by signals every fifteen minutes from a master clock, by which an alarm may be given, the time given, and/or a card bearing orders or announcements printed. A ratchet wheel is stepped one tooth every fifteenth minute and turns a disc fitted with holes to carry pegs, with which a contact spring makes contact to complete a bell or indicator circuit.
*	22.1.1889 1122 Hunt, E.	Gyroscopic clock having three gyroscopes mounted mutually at right angles in a gimballed frame held in the vertical position by a weighted rod below the centre of gravity, the whole assembly being mounted in a stand. The gyroscopes may be driven electrically, and to determine the time the apparatus is set with its axis parallel to that of the earth's, on which the stand revolves with the earth and the centre frame appears to revolve once in twenty-four hours.
	1.3.1889 3671 Boult, A.J. (Pouchard.R.J.)	Winding mechanism employing two forms of electromotor, both using electromagnets for the armature and a permanent magnet for the field. Also synchronizing by a lever which can stop an escapement if fast or allow it to run if slow, until the hour correction signal resets the minute hand to exact time. Several other proposals are made, by fitting a cam rotating once in twenty-four hours and another rotating once per hour, a lever carrying a roller can change the local circuit to alter a telegraph line to act as a synchronizing circuit with signals from a master clock sent hourly.

ELECTRICAL HOROLOGY PATENTS

* 1889	15.3.1889 4530 Price, H.S. & Dowsing, H.J.	Electric hour glass with filling of mercury or metallic powder, having two contacts sealed into each bulb. If mercury is used then the bulbs are exhausted of air, alternatively an inert gas may be employed, in which case a relief bypass is necessary to allow the gas to flow from one bulb to other. The device is intended for coin-operated apparatus for supplying electrical energy, when the paid time has expired, a lamp is lit and the current switched off.
	22.3.1889 5084 Boult, A.J. (Pouchard, R.)	Secondary clock mechanism driven by an electromagnet when energised at one minute intervals from a master clock. The armature operates a pawl acting on a sixty tooth wheel to turn the minute hand. Synchronization of the minute hand at the hour is also incorporated. If the clocks are slow, they are first made fast by a keyed circuit.
	8.4.1889 5976 Leyland, A.	The hour hand arbor of a clock carries a dial with the hours and quarters numbered in the reverse way to the main dial, and carrying forty-eight teeth and forty-eight sliding pins, one of which is pushed in opposite the time required for an alarm signal. At the required time, the pin makes a contact and rings an electric bell, this repeats every quarter of an hour until reset by hand.
	16.4.1889 6520 Thompson, W.P. (Gunther, - & Hoppe, L.)	Electromotor for driving secondary clocks by means of an electromagnet and armature driving a disc by a friction ratchet lever pulled by a spring, periodically a pivoted armature tilted to a permanent magnet causes contacts to close and energise the electromagnet, thus arming the driving spring.
	2.5.1889 7337 Jacomin, J.	Winding by a governor controlled electromotor geared by a worm to a two-arbored striking train, the latter geared to a winding barrel. At the hour a pin lifts a lever which falls when the hour is struck, making contacts to energise the electromotor which then runs until the lever is restored and the contacts reopen to break the circuit.
	8.5.1889 7689 Spink, J.M.	Currents transmitted from a master clock to indicators when a weighted lever falls into a notch of a disc driven by an escapement, and makes contact with a fixed terminal stud. The lever is replaced by the pendulum. The distant clocks have simple electromagnet and ratchet wheel mechanisms.
*	29.7.1889 12,017 Sherlock, D. & Eshelby, J.	Weight driving apparatus consisting of an electromotor which forms the driving weight and winds itself up after each descent. The weight slides up and down two conducting rods and on falling to its lowest position it shorts out contacts to rewind the weight; on reaching the top position the current is cut off and the rewinding ceases. The electromotor has four field electromagnets, the armature three, there are four contact brushes and a three-way commutator. The operating parts of a secondary clock are described also.
*	28.9.1889 15,272 Burrell, A.G.	Synchronizing apparatus for distant clocks at subscriber stations worked by electric currents from a master regulator, for which purpose it is fitted with relays having contacts dipping into mercury cups to make the necessary changes from telephone to time use of the lines for a short time. The indicator clocks can carry the telephone currents without being affected, but on receipt of a sustained direct current, an oil damped delay relay acts.
	14.10.1889 16,144 Hayman, H. (Gundersen, A.)	Time divided paper disc driven by clockwork is pricked by needles when electromagnets corresponding to the visited stations have their circuits completed by pressing buttons, thus a record is made of the watchman's round of inspection. The apparatus is kept in a locked case to prevent tampering with the indications.

1889	19.10.1889	16,564	Lake, H.H. (Morgan, F.E.)	Winding of a spring barrel by a ratchet wheel pulled round by a driving dog attached to an armature and held up by a spring. An arbor on the clock carries an arm tipped with insulation to first lift a lever and then contact a metal step. This attracts the armature of an electromagnet, pulling the dog down against its return spring. An auxiliary lever and contacts cause the circuit to be repeatedly made and broken until the arbor arm leaves its lever.
1890	20.1.1890	977	Dickie, M.	Electric alarm using a clock having a finger turning with the hour hand to make contact with two springs to complete the circuit of one or more electric bells. A switch is incorporated so that the person roused may turn off the bell. A dry battery is preferably used and attached to the clock. The finger and a setting dial are fixed on the arbor of the hour-hand of the clock.
	24.2.1890	2957	Aubert, F.J.A.	Apparatus for registering the duration of an electric current by it causing a solenoid with a fixed and moving core lifting a detent from the balance or pendulum of a clock. For use with alternating currents, the sliding core is made from a bundle of soft iron wires.
	4.3.1890	3484	Schweizer, E.	Currents from a master clock to energise an electromagnet and armature to advance the minute hand wheel of a clock. An anchor is fitted to ensure that the ratchet wheel can be stepped once only for each impulse from the master clock.
	12.3.1890	3872	Peyman, E.R.	An arrangement whereby a frame holding a dinner gong has a clock mounted on the top with adjustable contact pieces on an insulated conducting ring. Behind the gong is a hammer operated by an electromagnet connected to two wet Leclanche cells, the circuit being completed when the hour hand of the clock makes contact.
	19.4.1890	5947	Crosbie, M. & Warwick, B.W.	Apparatus by which a clock is caused at any required interval to complete the circuit of an electromagnet actuating a recording apparatus. The hour wheel, minute wheel and seconds wheel make simultaneous contact with studs and a detent is withdrawn from a paper drum receiving the record and advanced by a weight or spring.
	28.4.1890	6490	Schweizer, E.	A heavy armature worked by an electromagnet carries a pawl to advance the minute hand and a long lever bearing a rack acting on a loose pinion on the escape wheel arbor connected by a pawl and ratchet wheel to drive the escapement. A contact on the minute wheel energises the electromagnet, the current being turned off by a "V" rocker switch worked by an arm on the armature.
	30.4.1890	6652	Key, E.J.	Clepsydra for use in timing periods of illumination for exhibiting microscopical objects on the insertion of a coin. A compartmented water clock is used to regulate the period allowed and it closes and opens electrical contacts controlling an electric lamp.
	1.5.1890	6726	Hefner-Alteneck, F. von.	Making use of electric light or other distribution systems to synchronize secondary clocks by setting into action a mechanism at the secondary clock by a momentary reduction in the line current, either by hand or automatically by a master clock. An armature is just held at the normal current and released when the current falls to force a beak between two pins on a wheel of the train and correct the minute hand. Also describes a winding mechanism.
	3.5.1890	6878	Schmitz, R.	Cam operated timer with making and breaking contacts operated by cams which can be set on a sleeve rotating once in twenty-four hours. This may be used to operate separate alarms or sets of alarms at regular periods. Spring loaded levers moved by the cams switch the necessary contacts.

ELECTRICAL HOROLOGY PATENTS

1890	16.5.1890 7670 Abel, C.D.	Chronograph for registering the duration of an electric current through electric lamps. A centrifugal governor controlled electro-motor runs at constant speed so that a revolution counter indicates the duration of running, or the device may be used as a clock.
	12.6.1890 9124 Aubert, J.J.A.	Chronograph for registering the duration of a current. A key switch turns on the current and simultaneously removes a detent acting on the balance of a clock. Turning off the current stops the clock, the elapsed time gives the duration of the current flow.
	12.9.1890 14,393 Lucas, W. & Garrett, T.A.	Tell tale clock for watchmen using a chemically prepared paper which gives a coloured trace when an electric current is passed through it from a metal stylus to a metal plate supporting the paper. The record can only be made at definite times when the clock closes an electric circuit by means of contacts.
	10.10.1890 16,124 Fairgrieve, D.	A pendulum rod alternatively touches contacts on two pivoted arms, the left hand one removes a detent from an armature whose fall impulses the pendulum. Swinging back the pendulum rod contacts the other arm and energises the electromagnet to return the armature and reset it in the detent. Similarly the same contacts advances secondary clocks and also, through another mechanism, operates distant gongs.
	16.10.1890 16,463 Abel, C.D. (Mayrhofer, K.A.)	Systems for clocks, synchronizing and rewinding. The primary clock is wound by an anemometer type rotor using using compressed air. Contacts are fitted to send reversing currents to distant clocks. Pneumatic working of secondary clocks can be achieved by using the current to exhaust a pneumatic conduit by means of water passing through ejectors through the use of an electrically operated valve. The resulting vacuum can be used to wind primary and secondary clocks.
	22.11.1890 18,993 Prokhoroff, N. & Fanberg, N.	Electrical generator whose armature is rocked through half a revolution in alternate directions in order to transmit current reversals through a secondary clock circuit. The primary clock going train releases a weight or spring driven train to rock the armature rapidly, the secondary clocks have a central pivoted armature turned by an electromagnet energised by the current pulses and held by two permanent magnets after each half turn.
	1.12.1890 19,531 Garnett, C.J. Moore, A.	Tell tale clock having an inclined plane within with a series of hinged lid compartments which open in succession from the lowest to the highest by armatures of electromagnets energised in turn at given time intervals. Checks inserted into the clock automatically drop into the particular compartment open at the time.
	30.12.1890 21,195 Fuller, I. de K.	Tell tale clock fitted with an electromagnet and armature for every two stations on the inspection round., operated by key switches to close the electric circuit and cause the number of the station to be printed on a rotating time card. A rotary stepped switch programmes the station circuits when each station is keyed in turn.
1891	13.1.1891 641 Hammer, E.G.	Electromagnetically reset lever winding a light spring through a pawl and ratchet wheel which turns a train controlled by a balance wheel. A wheel turning once a minute operates a contact to energise the electromagnet whose armature not only resets the weighted lever but drives an indicating mechanism of the cyclometer type with three indicating discs, two for minutes, the third for hours. An ordinary clock dial is also provided.
	27.2.1891 3592 Whitehead, W.	Ordinary alarm clock fitted with electrical contacts which operate when the mechanical alarm sounds to complete a circuit containing a battery and bell, and a hand switch to break the alarm circuit.

ELECTRICAL HOROLOGY PATENTS

1891	28.2.1891 3650 Pope, L.	Pendulum reciprocating an insulated slide having a centre inlaid contact strip touched by a contact brush to pass current through an electromagnet placed slightly to one side of a pendulum to attract an armature mounted on the bottom of the pendulum. Motion is imparted to a clock train by a ratchet wheel to drive the hands.
	11.3.1891 4392 Entwistle, W.	Electrical bell with its battery enclosed in a case which has two terminals on the top and on which an ordinary alarm clock may be stood; one of the clock feet being insulated and goes to a contact operated by a step wheel and spring inside inside the clock. Other arrangements are described.
	24.3.1891 5192 Scales, W.S.	Electrically maintained pendulum clock impulsed every swing by a weighted arm released when the pendulum contact touches a gravity arm contact, the electromagnet armature is attracted and allows the gravity arm to fall until a stop is reached and the contact opens.
	3.4.1891 5774 Ritchie, J.	Mechanism to to operate gas cocks and ignite the gas by electricity, controlled by an escapement moving switches to complete the circuit for each of the burners to be lit.
	13.4.1891 6273 Bennett, H.	Combined night light, time indicator and alarm. A candle is placed on a helical spring and its weight counter-balanced by a chain attached to a light spring barrel which indicates the hours on a translucent disc. The pointer may be fitted with a contact to operate an alarm at the required time (or thereabouts).
	16.4.1891 6584 Rothwell, F.	Alarm clock stood on a box containing a bell and battery. A series of holes round the dial takes a plug on the end of a lead, and a separate set hand travels with the hour hand to touch a pin at the appointed time, closing the contact and sounding the alarm. The clock glass can be twisted and has a single hole for passage of the plug!
	20.4.1891 6773 Orth, L. von.	Use of telephone or telegraph lines to transmit synchronizing currents from a master regulator to branch clocks. Each branch clock closes a local circuit shortly before synchronization is due and switches the line to a local relay, the master clock closes the circuit to increase the current slightly and the hands are adjusted, upon which the line is reswitched to normal use again.
	13.5.1891 8183 Fitzpatrick, H.D. (Schubardt, S.)	A clock has electrical connections for sounding alarm bells in different rooms. A contact pin may be placed in one of a series of holes round the dial. By using several pins the clock sounds selected bells or a coupled series of bells at different times. In a further modification, several hour hands are fitted.
	26.5.1891 8922 Prentiss, H.S.	A master clock operates a transmitter sending currents each minute to control the escapement of secondary clocks driven by springs, and at longer intervals to synchronize the hands in case the clocks have not kept time. Circuit arrangements are made at the master clock and at the secondary clocks to allow the setting to time of clocks either fast or slow.
	25.6.1891 10,840 Der Ploeg, G.L.J. van.	A compensated pendulum is enclosed in an airtight case and makes and breaks the contacts of two electromagnets, one of which gives impulse to the pendulum, the other drives the hands. The armature impulsing the pendulum does so by means of a spring. For some reason the battery is shorted out when the pendulum is in the centre position, the reason is not stated.

ELECTRICAL HOROLOGY PATENTS

17.7.1891 12,150 May, W.R.	Electromagnetically maintained pendulum having a soft iron armature attached below the pendulum bob carrying a wedge-shaped piece to bridge two contacts when the amplitude of the pendulum falls to a predetermined minimum level, alternatively the contact may be in the form of a fixed pin surrounded by a spring helix which when set in motion by a lateral blow, repeatedly contacts the pin. A modified form of Hipp toggle switching.
31.7.1891 12,982 Wetherfield, F.G.M. (Jardine, C.K.)	Time check clock which places checks in chronological sequence in a drawer, with a semaphore to indicate "early" or "late" through an aperture. The hour hand of the clock carries a brush contact to bridge the space between two studs on the figure circle of the dial of the clock.
20.8.1891 14,084 Appleton, J. & Burbey, W.	Tell-tale clock placing checks into different compartments by the action of an electromagnet retracting stops at intervals when energised by contacts within the clock.
8.9.1891 15,243 Wells, L. de L.	Chronograph for ascertaining personal reaction time. A drum carrying smoked paper is rotated by clockwork, the paper being marked by a tracing style carried by a tuning fork tine; the tuning fork being maintained in motion by an electromagnet mounted between the prongs. The observer looks down a cone at a hole and this is covered by a shutter, the tracing style being lowered to mark the paper at the same time. The observer presses a button as soon as he sees the shutter fall, this lifts the style from the paper, the number of sine waves traced on the paper and the known frequency of the fork allowing the time of reaction to be ascertained accurately.
2.10.1891 16,467 Mathieu, D.	Electrical arrangements for causing a distant bell to strike, the bell being used at other times for ordinary striking (tower bell). An ordinary clock fitted with gong striking causes a spring contact to make and break when the hammer strikes, operating a circuit to cause an electromagnetic striker to sound the hours at the distant bell in sympathy. (Note the ordinary clock striking is too rapid for a tower bell).
13.10.1891 17,383 Kipping, P.P. Anders, G.L.	Automatic time switch for trunk line working whereby clock signals are sent to subscribers with telephone or telegraph lines. A vee projection moved by an electromagnet armature adjusts the minute hand by engaging a notched disc on the minute hand arbor.
20.10.1891 17,971 Du Laney, J.W. Du Laney, C.F.	Electromagnetically rewound spring via pawl and ratchet wheel to drive a pendulum clock train. One pallet is entirely covered with a plate of insulating material, the other only half covered. A special escape wheel is used with one tooth offset, so that once each revolution the tooth contacts the metal of the pallet and the electromagnet is energised.
18.11.1891 19,996 Nicholls, J.	Ordinary alarm clock which releases a pivoted terminal at the appointed time, allowing it to be pulled into contact with another terminal by a spring, thus causing an electric bell to sound.
15.12.1891 21,923 Berry, F.H.	Ordinary clock with escapement and pendulum driven by an electric ratchet, the pawl lever having a fork which is acted on by the weight moving up and down a vertical rod. A counterweighted lever is acted on by the fork when the weight descends and closes the electromagnet circuit and an armature lifts the weight to its initial position. A small permanent magnet holds the switch lever until struck by a set screw on the under arm of the fork, in order to ensure contact for a sufficient length of time for rewinding.

ELECTRICAL HOROLOGY PATENTS

1892	23.1.1892 1365 Bartlett, A.	Chronograph for starting and timing races consisting of a stop-clock, galvanic battery and starting device placed at the winning post: at the start is an electric relay, battery and and an electro-magnetic-ally operated bell or gong. The clock has contacts, also a lever to which the finishing tape is fixed, when it is broken by the winner the lever stops the balance of the clock. An electrically operated starting-pistol and a flag may be connected into the circuit.
	28.1.1892 1737 Boult, A.J. (Ellis, F.A.)	A pin on the escape wheel of a standard clock wipes a spring terminal once every minute to complete the circuit of a distant electro-magnet operating a secondary clock by a rod hanging from the armature through a pawl pushing the ratchet wheel tooth by tooth, advancing the minute wheel arbor and motion work.
	1.3.1892 4025 Miller, W.H.	Clock for ringing a bell or operating any other signal by fitting a number of insulated contact pieces over which the hour or minute hand passes. The contact pieces are connected to a corresponding number of pegs arranged in a circle. A radial arm or wires may be used to connect the bell circuits as required for calling persons in hotels, hospitals, giving notice of meal times etc.
	9.3.1892 4691 Scheizer, E.	Periodic currents are used to energise an electromagnet to attract a detent to allow one revolution of an arbor of a spring driven train to occur each time, and the armature also winds the spring of the train; by means of contacts operated by the train cause reversed currents to be available to external circuits through terminals fitted to the case of the apparatus.
	26.4.1892 7833 Walker, J. & Hampshire, J.	Metronome kept in motion by a soft iron armature mounted at right-angles to the pendulum rod at its centre of oscillation. Two solenoids surround this armature, one end of the winding going to a battery, the other to a pin on the pendulum which moves over two springs insulated on the insides so that the pin makes contact with one only at each swing, completing the circuit for impulsing.
	13.5.1892 9136 Thorn, R.	An ordinary alarm clock is fitted with a pulley on the arbor of the alarm spring and carries a cord attached to an electrical spring contact. As the alarm sounds in the ordinary way, the cord closes the contact on to a bar, completeting an electric circuit of a bell.
	24.5.1892 9880 Thompson, W.P. (Holt, C.F. & Star, W.S.)	Mechanism for altering a pair of hands either fast or slow by means of periodic currents from a master clock. An electromagnet causes the oscillation of a pivoted armature advancing a toothed wheel by a pawl to set the minute hand, another wheel gearing with this has only one tooth to turn the hour wheel arbor one step for each full turn of the minute hand.
	11.6.1892 10.999 Webber, A.B.	Device for impulsing a balance wheel by attaching an iron armature vibrating between the poles of an electromagnet. The arbor of the balance carries a spring flap passing over a fixed serrated block until the amplitude of swing falls and the end of the flap catches in one of the serrations and causes two contacts to close and energise the electromagnet, impulsing the balance. A pin on the balance moves a lever which turnes a wheel driving the train.
	16.6.1892 11,316 Vianen, G.W. van.	Alarm clock system using a plug switchboard connected to bells in rooms, and also to contacts spaced at half or quarter hour intervals surrounding the clock dial. A disc turning with the hour hand of the clock between two contact springs carries a wiper to run over the series of contacts, completing the circuits of the required bells for which the plugs are inserted.
	20.6.1892 11,493 Phillips, A.	Consists of a clock fitted to the head of a bed which may be fitted with an electric alarm to wake the occupant of the bed at any time required. It may be arranged to give a shock to the sleeper or [illegible]

ELECTRICAL HOROLOGY PATENTS

24.6.1892 11,822 Aron, H.	Winding mechanism consisting of a driving weight pivoted on the winding arbor of a clock and carrying a rod which makes contact as it reaches its lower limit, completing a circuit and the electromagnet attracts its armature thus throwing up the weight whose inertia carries it upwards when the armature stops, thus breaking the circuit. A pawl on the driving weight lever turns the ratchet wheel connected to the winding arbor. A spring bears on the rod, and to make the action more certain, an insulated block is placed as an insert at the position just before the point where the upward motion from the armature ceases, thus cutting off the current.
24.6.1892 11,822 Aron, H.	Two wheels gearing with a train of wheels are loosely mounted on a common shaft and meshing with an independent planet-wheel. If the two trains vary in speed, the planet wheel turns with a speed corresponding to the difference in speed between the two wheels. This mechanism may be used to allow one winding mechanism to drive both going and strike trains of a clock.
13.7.1892 12,888 Orth, L. von. Breslauer, E.	Synchronisation of a pendulum clock by a current sent a few minutes before the hour and broken exactly on the hour. Either a crutch or a gravity arm is held off the pendulum rod so that the clock train is not driven, being released exactly on the hour. The clock must have a small gaining rate.
1 .7.1892 13,141 Raap, G.	Primarily a clock driven by wind motor. An air driven wind-wheel is mounted below a conical pendulum and drives it through a slotted crank, the whole being mounted in a tube connected to another vertical tube containing a heat source, gas flame or electric lamp, the action being similar to the vanes in an electric fire for producing flickering flame effects.
9.8.1892 14,363 Gardner, W.F.	Transmission and reception of signals for the synchronization of a series of clocks, either by a special circuit or by telegraph or railway signalling lines. Relays and pole changers control the circuits for the various duties, and the secondary clocks are put to time by rods bearing on cams on the hour and minute arbors.
20.8.1892 15,038 Vidal, A.E. & Hervieu, G.	Winding of a light mainspring by means of a solenoid after it has run down some way. There is a ratchet wheel on one of the arbors of the movement whose teeth periodically close a pair of contacts to energise the solenoid. the iron core is drawn in, moving a lever fitted with a pawl to turn the ratchet wheel and wind the spring, at the end of its travel it opens the electrical contacts.
17.9.1892 16,624 Fairall, G.W.	Winding mechanism intended mainly for electricity meters operated by clockwork but suitable for independent clocks. Basically a spring wound clock fitted with an electromagnet operating a ratchet wheel. A star wheel on a suitable arbor of the clock is used to control the switching operations, once an hour, day or week as required. Although intended for electricity meters, a battery is used for the rewinding process.
22.11.1892 21.273 Ethridge, M. van B.	A beam is pivoted at its centre, one arm consists of a cylinder containing a sliding frame fitted with electric contacts and a free ball, the other arm is counterweighted so that with the ball and frame furthest from the centre, it is biassed to fall, overcoming the weight to make the ball roll towards the centre. In rolling inwards, the ball strikes the sliding frame to separate a pair of contacts, opening the circuit of an electromagnet which up to then had been holding up a weighted lever and now falls on the cylinder. The beam is driven back the other way, the ball rolls outward, striking the frame in the opposite direction to close the contacts again. The beam therefore oscillates and drives a ratchet wheel by means of a pawl to wind a spring controlled by an escapement [illegible]

1892	28.11.1892 21,660 Kean, J.	Clock for use with an electricity meter. the first arbor of the train is driven by a pawl-bearing weighted lever pulled down by a heavy vertical rod suspended from the armature of an electromagnet. An extension of the rod oscillates a rocking lever, causing a small mercury tube to open and close the electromagnet circuit. A maintaining spring is fitted between the ratchet wheel and the driven arbor. For use with an ordinary clock, the electromagnet is fitted below the ratchet lever and connected by a cord stretched by a weight.
*	2.12.1892 22.073 Chesterton, W.J.	Candle clock which may be arranged to ring an electric bell or switch on an electric lamp. A loose-fitting metal cap is supported on a candle, and it bears a ring which casts a shadow on a transparent scale to show the time. To ring a bell a wire is fixed to the cap, and the other wire goes to a bent lever mounted on a vertical rod so that at the required time the cap descends and makes contact to complete the circuit at the appointed time (or thereabouts).
1893	9.1.1893 434 Twigg, R.H.	Electromagnetically rewinding of a clock, the ratchet wheel of which is used to rock a lever carrying a small mercury switch, alternatively an arbor carries a commutator to make and break the electromagnet circuit as required. In case of the battery weakening, the armature descends lower than normal to activate a relay and switch in other cells to maintain the action.
	25.1.1893 1697 Binswanger, G. & Coates, H.J.	Electric clock maintained by a gravity arm held to one side by an electromagnet armature biassed by a counterweight until the pendulum rod makes contact with the gravity arm contact. A detent on the armature then releases the gravity arm and the pendulum receives impulse until the contact is broken and the armature in falling back raises the gravity arm by the detent. The clock train is driven by the usual pawl and ratchet from the electromagnet armature. In a modification the contacts short the electromagnet, however the action is the same but requires more power from the battery.
	9.2.1893 2887 Lateulere, A.A.	Toothed gearing, which among other things may be used for communicating motion from a small electric motor to wind up the spring of a clock, and may be provided with a device to disconnect the drive gear when the spring is fully wound. The motor drives an arbor fitted with a worm engaging with a wheel driving an arbor having a pulley to drive the clock winding.
	9.2.1893 2922 Scott. H. & Burnet, H.K.	A bell crank pivoted on a pendulum has its movement controlled by a radius arm so as to turn a ratchet wheel having six teeth. Once or more in a revolution, a pin (or several) bridge the gap between two springs for closing the circuit of an electromagnet mounted to one side of a pendulum to attract the soft iron armature fixed to the end of the pendulum rod. A balance wheel may be used, attracting an armature fixed diametrically on its arbor.
	8.3.1893 5064 Cauderay, J.	An oscillating balance carries a spring pawl on its arbor which drives a crown wheel turning a train to move minute and hour hands. A small armature oscillates between two poles of an electromagnet, and when the amplitude of the balance falls, a cam with a notch picks up a tongue on a lever and forces the lever down to close two electrical contacts, energise the electromagnet and impulse the balance through the armature on the balance arbor. (A modified form of the Hipp toggle mechanism.)
	23.3.1893 6233 Du Bois, E.	The train of a clock is driven by a ratchet mechanism under the action of a spring or weight and electromagnet. In the example shown, the third wheel wheel carries a pawl engaging the ratchet wheel which is connected by a link to a long flat spring, the spring is raised by the electromagnet and then drives the clock when the current is cut off. [illegible]

ELECTRICAL HOROLOGY PATENTS

3 6.4.1893 7115 Simkins, A.R.M.	Electrical chronograph driven by currents sent at minute intervals from a master clock. An electromagnet attracts an armature which turns a ten toothed ratchet wheel, a dial on the same arbor indicates minutes. By means of a pin, a second dial showing tens of minutes is turned, this moves a third dial showing hours. For large versions of this apparatus, all three dials may have separate electromagnets to drive them.
2.5.1893 8830 Campiche, M.A.	Near the top of a pendulum rod is fitted an arm driving a countwheel with an arm which passes between two spring contacts to complete a circuit to operate secondary clocks. Included in the circuit is an electromagnet whose armature is counterweighted to give an impulse to the pendulum when the armature is attracted. The armature is returned by the pendulum rod carrying a rod projecting from the pendulum rod, on the return swing before impulse takes place. The impulse depends on the strength of the current.
25.7. 14,318 Wiseman, A.G.	Electrical rewinding of a spring winding a clock, a cam band on the barrel operating the electrical contacts through levers, electrical brushes and pins. Also electrical synchronizing of a clock which is slightly fast where shortly before the hour a pin on the hour wheel causes several connections to be altered, on the hour the escape wheel is unclutched from its arbor and the seconds hand runs to a stop, whilst a tip is forced into a notch of a disc attached to the minute wheel arbor to set the minute hand to time.
14.8.1893 15,450 Franke, A.	A separate operating current is sent to each secondary clock from a standard clock, the durations of the currents are indicated or recorded so that the condition of each clock is known. The current to each clock may be used to cause an electromagnet to open the valve of a water aspirator to operate the synchronizing or winding mechanism.
24.8.1893 15,971 Anders, G.L. & Kottgen, W.	An electromagnetic motor which will rotate at a given and constant speed. A disc of magnetic material is mounted on a central pivot so it can be tilted successively by electromagnets arranged in a circle below it. A ball runs round a peripheral track and contacts a series of studs connected with the electromagnets below so arranged that the magnet just before the ball pulls down the disc, presenting an inclined plane for the ball to run down. It is stated that the motor may be used as a regulator to control other clocks.
18.9.1893 17.051 Fielden, W.	Consists of a stand having a vertical post bearing a centre-pivoted fork into which is placed the key of an ordinary alarm clock which winds the alarm train. When the alarm sounds and the alarm train key turns, the fork is rotated and completes a circuit of an electric bell.
10.10.1893 19,018 Davis, J.A. & Fowden, R.A.	Step by step electromotor having a spring loaded armature connected by a link connected to a frame which slides and bears pawls to actuate and control a ratchet wheel. A contact disc on the minute wheel arbor of the master clock provides the interrupted current to a series of subsidiary clocks.
23.10.1893 19.948 Boult, A.J. (Ayres, E.)	Secondary clocks operated by currents from a master clock. A wheel in the master clock has a set of tappets on opposite sides which trip triggers to complete the line circuit and a local circuit to an electromagnet which resets the levers on their detents after the current pulse is completed. The secondary clocks have a simple stepping electromagnet and a pivoted armature and an escapement bar to prevent excessive motion.
17.11.1893 [illegible]	Secondary clock worked by currents from a master clock, the ratchet wheel has teeth like an escapement wheel and is driven by a curved [illegible]

1893 8.12.1893 23,633 Parkin, J.	A spring driven clock has the going barrel replaced, and rewinding is accomplished by a ratchet wheel driven by a pawl on the extension of an armature of an electromagnet. How the clock is then driven is not made clear.
1894 9.1.1894 489 Herbert, E.	A pendulum periodically makes and breaks the circuit of an electromagnet, the armature of which drives clock hands through a pawl and ratchet wheel, and also impulses the pendulum. The top of the pendulum rod moves a metal block between two fingers to switch the circuit. When made, the electromagnet holds a gravity arm to one side and releases it when the current flow stops.
3.2.1894 2437 Bastos, A.A. Cardoso e.	Electric alarm. A metal arm clamped to the hour hand arbor sweeps round within an insulated rim to which are clamped a series of sockets, into which are placed plugs with a pin connection. To set the alarms the plugs corresponding to the times required are pulled out to expose the pins which are then contacted by the arm at the set times. Also described is a mechanism for a secondary clock, and an apparatus for transmitting minute pulses.
3.3.1894 4522 Boult, A.J. (Campiche, H.)	Secondary clock mechanism operated by an electromagnet and armature. A pivoted lever at right angles to the armature bears a shaped pallet working over a ratchet wheel with saw-shaped teeth, a spring pulling the pawl back after the action is complete, stop pins being fitted to ensure a clean action.
17.3.1894 5655 Cruyt, W.	Synchronizing apparatus applied to pendulum clocks. Each clock is set to run slightly fast, and a few seconds before the hour a normally stationary cam is set in motion, a lever falls and holds the pendulum to one side in a raised position. The synchronizing pulse from the master clock energises an electromagnet which allows the cam to reset and the pendulum is released. A further device within the clock restarts the pendulum if the master clock fails to do so.
14.4.1894 7484 Harben, N.	Alarm using an ordinary clock with an insulated disc on an arbor turning once in twelve hours. A cam bears on a pin which can be set to any time and contact is made for almost two hours before the current is broken, hence a prolonged alarm is given on an electric bell unless switched off manually.
25.4.1894 8186 Potts, R. Potts, J. & Potts, J.	Electromagnetic ratchet wheel to drive the hands of a clock when energised by currents from a master clock bearing a double arm on an arbor turning once a minute to give half-minute pulses by contacting a spring terminal to complete the circuit. Stops are fitted to the secondary clock mechanism to ensure correct action.
11.5.1894 9362 Bromhead, S.S. (Beuner, F.)	A board bears checks hung on pegs to remind the "boots" of an hotel when to call the guests, and an alarm clock set to all the times required. Pins corresponding to the required times are pushed in, the hour hand wipes them in succession to sound the alarm to alert the attendant who then calls the corresponding rooms indicated on the checks, the alarm and call bells being electric bells.
28.5.1894 10,292 Manger, J. & Mojon, E.	Watch dial illuminated by a small incandescent lamp, one terminal of which is connected to the metal watch case, the other terminal being connected to an insulated metal stud for connection to a battery. The dial is made smaller than usual to accommodate the lamp.
28.5.1894 10,366 Boult, A.J. (Meyer, E.A.)	Tell tale clock in which the master clock drives a shaft carrying a series of tappets to control indicator circuits. If the watchman does not close his circuit at the inspection station on receipt of an indication, the shaft is locked and an alarm sounded, plus a record made of the neglected station by a drop-down flag indicator.

ELECTRICAL HOROLOGY PATENTS

1894	29.5.1894 10,386 Fritz, F.	Alarm consisting of a spring driven clock with a hand sweeping over contact studs, connected to a switchboard whereby any room in an hotel, etc., can be called at any requested time. Wires with metal hooks are used to make the necessary connections to the rooms.
	12.6.1894 11,366 Gordelier, F.H.	Alarm system using a clock with contacts, the selection of the time and room is by placing a weighted disc on one of a series of hooks which then makes the appropriate circuit to ring an electric bell at the appointed time.
	17.8.1894 15,700 Watson, N.M.	Time stamp clock for registering the number of a watchman and his time of attendance at a station on a roll of paper. The main clock carries contacts to transmit motion by an electromagnetic device to turn printing discs every five minutes.
*	5.9.1894 16,884 Smith, F.J.	Chronograph for recording very small intervals of time such as that of the flight of a bullet between two points. A carriage is propelled by a spring or falling weight, the vertical face of the carriage is coated with lamp-black and an electromagnetic style marks the coating when the circuits of electromagnets are broken by the projectile in its flight. A tuning fork style also traces on the coating so that the exact time of flight can be obtained. To ensure uniform motion of the carriage, a flywheel may be fixed to one of the axles of the carriage.
	14.9.1894 17,498 Benest, E.	Electric alarm where a clock arbor turning once in twelve hours carries a loose wheel which can be set by an index. A notch in the wheel registers with a pin so that a spring completes an electric circuit. A make and break wheel may be included to give an intermittent alarm signal. After an interval the pin recovers its initial position and the circuit is broken and the alarm is silenced.
	24.9.1894 18,128 Jardine, C.K.	Tell tale clock where a contact making clock is used with a check receiving mechanism. The dial is perforated at quarter hour divisions for the hour hand, into which perforations are placed platinum tipped screws so that the tip of the hour hand touches them to complete a circuit controlling the check receiving mechanism.
	2.10.1894 18,673 Mouguin, H.F.	Synchronizing and rewinding of a secondary clock by currents from a master clock. A lever acted on by an electromagnet armature pushes a vee beak into a notch of a disc on the minute wheel arbor and it is immediately released when the hand is set. The current is maintained until the clock is rewound by an electric motor in series with the setting electromagnet, being connected by a train of gearing to the going barrel of the clock.
	10.10.1894 19,283 Wise, A.G.	Improvements to the electrical winding and synchronization of independent secondary clocks described in Specification No. 14,318 of 1883.
	20.10.1894 20,046 Thompson, W.P. (Marx, P.)	Registering chronograph driven by spring or weight or distant master clock electrically to show the times of working of machines. A push button resets the indicators to zero and starts the register. A record is made on a disc, cylinder or strip of paper by a pencil carried on a lever.
*	21.12.1894 24,876 Aron, H.	An armature attached to a spring oscillates between the curved pole pieces of an electromagnet, the current passing through the electromagnet to a pin on the armature and and one prong of a fork pivoted as a toggle. When the fork passes its dead centre, the pin strikes the other prong which is insulated, cutting off the current. The motion rewinds a light spring to drive the clock train by means of a ratchet wheel and two pawls. Stated to be specially suitable for electric meters fitted with clocks for measuring purposes.

1895 1.1.1895 82 Arnold, C.
An electromagnetically operated winding mechanism consisting of a weighted lever pivoted on the same centre as an armature. The contact system uses a small metal cross whose arms bear on a spring which has an insulated face except for a small contact surface at the end. As the weighted lever nears the end of its return, a projection on its arbor turns the cross through 45° so one arm wipes across the insulation and drops on to the metal contact, completing the circuit and energising the electromagnet and attracting the armature between two forked pole pieces; as it reached its maximum position, a small lever resets the cross for the next operation. The cords fitted to the armature and weighted lever transmit the motion to a pawl and ratchet wheel on the winding arbor of the clock.

23.1.1895 1587 Hope-Jones, F. and Bowell, G.B.
The first patent in F. Hope-Jones' name, there is reason to think that the mechanism was designed by G.B.Bowell, the principle involved being the transmission of mechanical force through a pair of electrical contacts to increase the reliability of the current path, but in this example relatively small. Two gravity arms have attached armatures, and each gravity arm contacts the pendulum rod to energise the electromagnet of the other arm, thus raising it for action ready for release when the contacts of the other arm separate, the difference in height between the position of the gravity arm on being picked up and when the pendulum rod leaves it being the amount of impulse energy imparted. Secondary clock mechanisms of various construction, an electromotor for a turret clock, a striking mechanism, synchronizing apparatus, and an interesting electromagnetic device for altering the length of the pendulum suspension to alter the rate, are also described.

8.2.1895 2805 Crowley, R.J. Cox, H.W. Leighton, C.F.
Synchronizing apparatus for secondary clocks by fitting an insulated metal ring on an arbor, having a brush connecting it to the main circuit and a contact stop. When all the clocks in the secondary circuit have their stops in contact with the armature of an electromagnet, the main circuit is closed and all the electromagnets energised to remove the stops and the clocks are freed. (It is not clear how this can correct the clocks since the circuit is governed by the slowest clock, presumably all must have a gaining rate).

11.2.1895 2969 Grossett, W.G.
A friction tight setting disc on the hour hand arbor carries an arm which contacts a jointed lever to complete the circuit of an electric bell. Other modifications are described.

19.3.1895 5798 Burry, J.
Chronograph driven by weight or spring motor automatically wound up by the action of an electromagnet whose circuit is completed by pre-arranged contacts. The electromagnet armature moves a lever with a pawl to turn a ratchet wheel arranged to drive a flywheel via a spring, plus other mechanical details, but how the winding is accomplished is not too clear, nor the contact arrangements.

23.4.1895 8049 Thompson, W.P. (Knapp, H.W. & Gerrety, L.E.)
An insulated ring surrounds the dial of an ordinary alarm clock and carries a series of contact fingers which can be pushed in for the time required for the alarm. A contact finger on the hour hand touches the contact finger selected at the appointed time and rings an electric bell. The fingers are provided with hooks to hang tags or memorandum devices, to remind the attendant.

20.6.1895 12,035 Phipps, T.J.
Mechanism for cutting-off gas or electricity at a given time. No electrical contacts are used, the action being transmitted by a cord to a gas cock or an electric switch.

6.8.1895 14,888 Wise, W.L. (Crehore, A.C.)
Electric circuit arrangements to obtain instantaneous records of rapid events such as the time taken by projectiles, by the projectile making and breaking circuits. When current passes through the circuit it energises a solenoid coil surrounding a glass tube containing carbon disulphide to alter the plane of polarization

395	6.8.1895 14,888 continued.	and twist a beam of light passing between two crossed Nichol's prisms, hence allowing light to pass through an aperture behind which is a sensitised film carried on a disc moving at constant velocity, thus a record is made of the duration of the event.
	14.8.1895 15,288 Lake, H.H.	A spring driven clock is fitted with a bar escapement and operated by currents from a master clock, the main purpose is to secure a silent operation. The escapement anchor is fixed to an electromagnet armature and biassed to one side to hold the bar, when current passes to energise the electromagnet, the armature turns through a small angle and releases the escapement bar which then flicks through half a turn, held until the current ceases and then flicks through another half turn. The pallets are faced with small springs to deaden the sound.
	23.8.1895 15,884 Staveley, A.W. Parsons, J.H.	Tell tale clock having a paper covered drum driven by clockwork with printing styles operated by electromagnets to make a record by pressure on an inking tape. The drum is removed daily and this action moves the feed gear of the ribbon to print from a new portion.
	24.9.1895 17,782 Wall, G.	An alarm clock in which the circuit of a sounder is completed by the hour hand pressing two spring contacts together, these being situated on a radial arm fixed to a rotatable metal ring for setting to the required time.
	10.9.1895 19,055 Franke, A.	A small correcting or rating clock is placed under the clock to be corrected, the dial of this clock having a pointer passing through one turn in say twenty seconds, the sub-divisions being one-tenth seconds. Shortly before the daily signal from the regulator clock is received, a local circuit is completed and the correcting clock starts but is automatically stopped at the lowest part of the dial, or zero. The regulator clock gives a signal at some convenient time and starts the correcting clock and is stopped by the corrected clock about ten seconds later. If the correcting clock dial than reads zero, the clock is correct.
396	11.2.1896 3133 Wiesner, J. Witzel, A.	Electrically maintained pendulum which oscillates two bars on an arbor, causing two pawls to engage with two toothed wheels, one of which drives the usual train, on an arbor of which is mounted a regulating disc having a few indentations. A pivoted lever has projections which can engage in the teeth of one wheel and the indentations of the disc so that as the amplitude of the pendulum falls, it allows the attitude of the lever to change and engage a pair of contacts, closing an electric circuit to energise an electromagnet which attracts an armature fixed on the lower end of the pendulum rod. (A modified Hipp arrangement).
	14.2.1896 3375 Paynter, T.S. Walker, G.C	Alarm clock fitted with electrical contacts to complete a circuit and ring an electric bell for a short time. The hour hand tip touches a small spring contact carried on a revolvable glass disc which is set to the required time for the alarm. Two contacts may be fitted in close juxtaposition if two signals separated by a short interval are required, the outer end of the hand may be forked.
	28.2.1896 4445 Rigby, C.	A frictional arm is set on the clock winding arbor for the alarm train, and when the alarm goes off, the arm contacts a terminal to complete the circuit of an electric bell which sounds until the arm is pushed back against a stop by a small turn-button, this latter can also be used to give an alarm at any time by hand.
	6.3.1896 5045 Brooke Time Checking Clock Co. & Brooke, F.	Tell tale clock, the recording mechanism of which is controlled by an eight-day clock turning a drum covered with paper divided into hours and days. A rotary arm makes contact with a spring and closes the circuit of an electromagnet and alarm bell. A small portion of the paper is exposed for the signature of a workman.

ELECTRICAL HOROLOGY PATENTS

1896	1.4.1896 7140 Joyce, A.	Electromagnetically driven pawl and ratchet wheel mechanism for a secondary clock, the movement of the armature being limited by india-rubber pins, operated by currents from a master clock fitted with a rotary contact system of very simple design. If the arrangement is used to wind a master clock, a maintaining spring is fitted between the ratchet wheel and the train driving an escape-wheel controlled by pendulum or balance.
	17.4.1896 8163 Mesmer-Weber, L.	Electrical alarm system consisting of a clock which drives a spirally studded roller of forty-eight pins which revolves once in twelve hours. Plate springs make contact with pins at quarter-hour intervals to energise bell circuits in distant rooms and to move indicators in a central office. By incorporating an additional switch, the bells may be rung simultaneously for use as a fire alarm, etc.
	24.6.1896 13,975 Smith, A.D.	An insulated clock dial is pierced with holes at certain intervals of time, into which pegs or screws carrying contact pins may be inserted. Two concentric rings of metal at the back of the disc receive the the pegs and are connected to batteries controlling a drum for receiving workmen's checks. An extra ring may be added to sound an electric bell. To alter the intervals between contacts, the contact pieces may be turned out of the radial position.
	14.7.1896 15,616 Davidson, J. & Automatic Memorandum Clock Company.	A modification to the Memorandum Clock detailed in Specification No. 706 of 1891. A lever is fitted which is pivoted so that when a memorandum tablet drops into a holder fixed to the lever, the lever is depressed and closes an electrical contact, causing an electric bell to ring until the tablet is removed, the bell being contained in the base of the clock.
	17.7.1896 15,837 Dale, E.R.	A simple contact spring fixed to a gong block of a striking clock is connected to a circuit of a distant bell and the circuit completed when the hammer of the clock falls on the contact spring.
	17.7.1896 15,856 Pallweber, J. & Kolbe, A.	Chronoscopes and electric clocks which have an indication of time in minutes by vertical leaves on which the numerals are printed and are flicked over each minute. (Similar to the Plato clock). The tens figures are printed on the reverse of the units figures.
	25.7.1896 16,502 Whitehead, W.	Electric clock in which the driving element is an electromagnet ratchet with a loaded armature that is a lever of the first order. At the end remote from the electromagnet is a make and break switch, this allows repeat movements of the armature during a current period from a master clock, stated as once per minute.
	17.9.1896 20,579 Nicole, W.	Chronograph for checking, starting, and timing of handicap races. It consists of an ordinary clock mechanism having a centre seconds hand a buttons to start and stop it. Electrical contacts are fitted so that an electric bell may be rung. An electric striking system is described, also a dial having sixty holes corresponding to seconds and adapted to take pins which are contacted by a light spring on the end of the seconds hand to give a starting signal.
	22.12.1896 29,442 Barr, J.J. Hulet, H.A.	Illuminated clock dial for showing the exact time on pavements or walls, etc., this being done by means of an electric lamp which passes light through a transparent clock dial and then a condenser lens to project the image of the dial where required. The hands are secured to glass discs with teeth on the outside allowing a clock train to turn them without casting shadows. Another clock mechanism drives another glass disc which carries advertisements which are changed at suitable intervals.

ELECTRICAL HOROLOGY PATENTS

1896	29.12.1896 29,923 Laing, D.F.	An electric bell with a semaphore is placed in circuit with a clock, whose hands sweep over contacts on the dial and having dial switches set by hand to give the alarm at the required hour and minute.
	31.12.1896 30,088 Whitehead, W.	Electric clock mechanism similar to that in Specification No. 16,502 of 1896, but in which push and pull pawls act on a pin wheel rather than a ratchet wheel, also the action is assisted by a helical spring rather than a weight. The two pawls are linked by a small spring to keep them in contact with the pins.
1897	23.1.1897 1800 Stockall, W.H.	The current making and breaking of a master clock is accomplished by having two cams mounted on the minute arbor on which rest two levers bearing contacts. Steps on the cams allow the making and breaking of the contacts in a short space of time, the duration of the current to the secondary clocks can be altered by altering the cams in respect to each other. A receiving mechanism for a secondary clock is described, it has various adjustments to regulate the movements of the armature and pawls, india-rubber buffers being fitted to reduce the noise of working.
	1.2.1897 2581 Drew, A.E.	Electric alarm system for calling guests in hotels. There is an electric bell in each room with a two-way spring key. There is a switchboard connected to studs on the dialof a clock which are contacted by the hour hand, chained plugs being put into the switchboard to select the time required. When the guest turns off the alarm in his room, a reply signal is automatically sent.
	9.3.1897 6.2.1897 Staveley, A.W. Parsons, I.H. Murday, T.J.	A roller on a pendulum rod lifts a bevelled lever and causes a pawl hanging from the lever to drive a ratchet wheel on the arbor of a minute hand. The pendulum is impulsed by an electromagnet whose armature bears a hook to pull the rod when the armature is attracted. Mounted on the pendulum rod is a small pivoted lever freely passing over a block until the amplitude falls and the block is forced downwards to make a spring contact touch another and the electromagnet is energised. It can be modified for use with a balance.
	25.3.1897 7692 Whitehead, W.	Tell tale electric clock having a time stamp so that when a workman arrives he presses his numbered slip into a funnel and an impression of the time and number is made on a paper tape. The time clock is controlled from a regulator clock.
	25.3.1897 7693 Whitehead, W.	Improvements to the mechanism described in Specification No. 21083 of 1891 and No, 8513 of 1894, the device being in the form of a hand stamp and the time is printed in hours and minutes, and dating wheels can be fitted. The time stamp is worked by current at minute intervals from a master clock.
	26.3.1897 7868 Hope-Jones, F. & Bowell, G.B.	1. Improvements to Specification No. 1587 of 1895, where by the gravity arms are detached from the electromagnet armatures and are thrown up when the arms leave contact with the pendulum rod. 2. A clock movement including an escapement with pendulum or balance is driven by a gravity or spring ratchet lever which sinks until a pair of contacts are closed at the armature lever, upon which the lever is thrown up another tooth of the ratchet wheel, simultaneously breaking the electrical contacts.
	15.4.1897 9675 Hennequin, L.A.A.	A clock is driven by a spring lever acting on a pawl and ratchet wheel, the action being maintained by an electromagnet. The circuit is made and broken by a pronged fork on the lever acting on a bell crank lever which is spring biassed to jump into and out of contact with the upper part of the fork, the lower prong being insulated. A resistance shunted across the contacts reduces the sparking. A striking mechanism and alarm are also described.

ELECTRICAL HOROLOGY PATENTS

1897	30.4.1897 10,766 Thrasner, S.P.	Clocks which have electric lights to illuminate the figures carried on transparent flexible revolving bands. A master clock causes the circuit controlling the electromagnet stepping mechanism to be closed once a minute.
	5.5.1897 11,243 Eibig, P.	Electrically wound clockwork fitted with a differentail mitre gearing operated by an electromagnet armature pulling a lever. The current is controlled by a complicated mixture of mechanical devices and electric contacts.
	18.6.1897 14,741 Skee, G.H.	Alarm clock fitted with an arm on the hour hand arbor which drops contact wires at the hours to a wire lifted for the day by a wheel having seven pins of different length and fourteen equal pins moved by an arm on the hour arbor to turn the pinwheel once in seven days.
	19.8.1897 19,181 Wildermann, M & Mond, R.L.	Chronograph having a fixed drum covered with paper, a bar carried on supports holds a stylus which rotates about the cylinder, the stylus being moved to the left to interrupt the trace by means of an electromagnet in order to mark an event.
	23.10.1897 24,554 Lord, J.E.C. Allan, H.	The seconds wheel of a master clock closes a circuit once every revolution so that a lever in a secondary clock is attracted by an electromagnet to move a pin-wheel through a precise angle by a hook, the motion being limited by stops and a roller coming into contact with a star wheel. The hands of the secondary clock are geared to the pin-wheel.
*	31.12.1897 30,917 Burk, R.	Electric clock with driving pendulum whose potential energy is restored by an electromagnet. Situated on the pendulum bob is a pawl driving round a ratchet wheel fixed on the plate of a clock mechanism, two metal guides ensuring that only one tooth is moved per oscillation of the pendulum. Two electrical contacts are bridged when the amplitude of the pendulum falls below the thickness of a tooth, the pawl then catching a pendulum lever which then depresses a second lever to make the contact, thus closing the circuit to energise the electromagnet maintaining the pendulum. (Modified Hipp).
*1898	4.1.1898 242 Richard, F. & Leutz, T.	A balance with a spiral spring operates dial-work through an intermediate ratchet wheel, of which the operating gravity lever has a pivoted foot to let the driving arm pass freely on its return. The energy of the balance is restored by an electromagnet which attracts a diametral armature either by currents from a distant master clock or locally as follows: Two opposing contacts on springs are normally separated and an arm on the balance staff sweeps past both ways over a freely pivoted pallet until the amplitude falls and the arm catches the pallet by a notch, forcing the spring contacts together and energising the electromagnet. A dry battery is housed in the base of the clock and is made easily removable.
	20.1.1898 1564 Whidbourne, H.	An electromagnet is used to strike a gong, the same action turning a count-wheel. The first stroke is struck by the clock itself, but subsequent strokes are governed by a subsidiary pendulum closing and opening the circuit operating contacts. A hook on the pendulum holds it up until the detent driving the ratchet wheel drops at the first stroke on the gong.
	9.4.1898 5442 Marks, W.D.	A pendulum for an electricity meter is oscillated by an electromagnet acting on a curved magnetic arm, the circuit being made and broken by a loose contact arm which falls first on one side of a slot and then the other, one side being insulated the other forming a contact surface, the arm having a centre of gravity above its pivoted support.

ELECTRICAL HOROLOGY PATENTS

1898	15.4.1898 8832 O'Keanan, C.E.	Proposal for a counter connected to an electric motor having a constant magnetic field and supplied with a constant voltage to serve as a clock. (At the time it would have been much more difficult to have secured a constant voltage than make an accurate clock, but this would not have ensured constant speed because of changes in winding resistances with temperature).
*	17.5.1898 11,282 Reich, H.	Near and a distant bell sounded with a variable time interval between them by using a clock fitted with electrical contacts. The purpose is not stated in the abridgement.
*	13.7.1898 15,416 Witham, W.H.	Tell tale clock where the workman's face, ticket, and the time are recorded on a photographic film. The only electrical portion is that for night use an electric lamp is used, switched on by the workman pushing a rod; magnesium flash may also be employed. (Devised in preparation for 1984).
	15.7.1898 15,509 Whidbourne, H. & Ball, A.E.J.	Current from a master clock is transmitted each time an arm bearing two pins, and turning with the escape wheel, touches the lower notched end of a contact-key pivoted on the escapement anchor and actuates a contact during the locking of the escapement; during the movement of the anchor the contact-key is disengaged from the revolving arm. (The running of the regulator must be highly disturbed by all these operations).
	4.8.1898 16,902 Lake, H.H.	A ratchet wheel is driven by a pawl pivoted on a lever armature retracted by a spring. Contact is made and broken between the pawl and a contact screw in the check pawl to control the circuit of the electromagnet attracting the armature.
	22.8.1898 18,024 Drew, A.E.	Alarm system using a clock with an hour hand touching contacts spaced at quarter-hour intervals, these being connected to a switchboard into which plugs may be inserted to determine the rooms for which the alarm is to be sounded.
*	12.9.1898 19,337 Rudd, R.J.	Occasional momentary electric currents from a standard timekeeper are caused to alter the effective length of a pendulum by means of curb pins on the suspension spring should the secondary clock not be exactly synchronous. A snail on the seconds arbor determines the amount of regulation necessary by limiting the amount of regulation applied by the regulating mechanism when an electromagnet attracts an armature; if the clock is to time, then no correction is made. (Note this method will never settle down because if the clock indicates the correct time, the regulation will be fast or slow, and the rate will be correct when the indication is incorrect).
*	3.10.1898 21,224 Rosi, E. Vacotti, G.	Balance wheel driving a ratchet wheel by means of a pawl on the balance arbor. A detent pawl hits a strip terminal to make and break the electromagnet circuit, the armature of which has a forked lever engaging an impulse pin on the balance.
	25.11.1898 24,387 Millar, T.	Electric switch which is closed by a bell crank lever bearing pins that engage in three notched discs rotating respectively in seven days, half a day and an hour.
	17.12.1898 26,707 Ceschall, A. & Resch, C.	Synchronizing of secondary clocks by a pair of cranks acting on an arm fitted on the minute arbor of a clock through the action of an motor train. Also a master clock arrangement where an electric current is transmitted, preferably alternating, to make an electromagnet armature vibrate and cause a triangular lug to step down the teeth of a fork until the motor train is set free.

ELECTRICAL HOROLOGY PATENTS

98	19.12.1898 26,769 Andersson. H.E.	Rewinding of the mainspring of a clock by means of an electromagnet. The main contact breaker for the electromagnet circuit is a column of mercury divided by a mica plate. An electrically operated striking mechanism is also described.
	27.12.1898 27,324 Crane, R.T.	Clock dial fitted with transparent ring carrying the numerals, behind each of which is placed an electric lamp, as well one carried on the minute hand which is always lit, the others being switched on in succession as the minute hand sweeps by. The figures may be composed of lamps.
1899	9.1.1899 503 Belzon, E. & Royer, P.	An advertisement frame for use in hotels, having an electric clock at its centre actuated by a master clock in the hotel office sending a current once each minute. A guest wishing for an alarm bell at a certain time puts a plug into the appropriate socket in the rim of the clock, and a flexible hand parallel to the hour hand touches the plug in due course to sound the alarm.
	20.1.1899 1394 Stockall, J.J.	Electromagnetically operated ratchet wheel in which the teeth are cut especially deep to ensure that one of two pins is always in engagement before another can escape, ensuring that the wheel is stepped tooth by tooth.
*	21.1.1899 1438 Neill, S.D.	Electric clock specially for use as a turret clock. The pendulum drives a ratchet wheel bearing pins to form a make and break for an electromagnet ratchet gear to drive the hands. A worm reduction ensures that the hands cannot be driven backwards by the wind, etc.
	3.2.1899 2499 Vaudrey, P.V.	Tell tale clock with electrical arrangements to monitor the times of a watchman' visits to his inspection stations, and to provide a permanent record for the overseer to check the watchman and the manager's information.
	7.3.1899 4954 Butcher, J.	Electromagnetically rewound clock, a maintaining spring being fitted between the ratchet wheel and first wheel of the train. Also electrically operated striking mechanism consisting of a centre pivoted armature bearing an hammer on the same arbor to strike a gong, the number of strokes being governed by a rack.
	4.5.1899 9398 Golby, F.W.	Automatic rewinding of a clock using a small direct current motor with a pulley drive to a reduction gear mounted on the clock to be rewound, the reduction gear turning the mainspring winding arbor. On a suitable wheel is a pin contacting a spring to switch the motor on, the circuiting opening when the spring is wound.
*	17.5.1899 10,393 Campiche, H.	Impulsing electromagnet for maintaining a pendulum. A spring loaded pivoted lever follows an armature when the latter is attracted, and a long spring extension from the lever impulses the pendulum through its rod. A stronger spring attached to the armature forces the whole assembly back when the current ceases. (A spring remontoir released by the armature attraction, hence independent of the current strength.)
	18.5.1899 10,497 Bruck, F.	Alarm clock fitted with a contact operated by the alarm train winding handle when the alarm sounds. Completion of the electric circuit may be used to operate a camera, raise a curtain, fire a mine, etc. An electric lamp is switched on when device operates.
	27.5.1899 11,106 Siemens Bros, and Co. & Lauchert.E.F.H.	Circuit arrangements for a standard clock with a secondary clock circuit, the contacts are operated by double arms carrying rollers to depress one contact after another to give reversed driving currents through the secondary clock system, a resistance being brought into the circuit to reduce sparking as the contacts open.

ELECTRICAL HOROLOGY PATENTS

1899	15.6.1899 12,490 Brooks, A.G.	Use of mercury in a glass tube mounted on a pendulum rod to switch the current flowing through an electromagnet maintaining the pendulum. One platinum wire dips deeply into the mercury for a permanent connection, the other wire makes and breaks the circuit as the level of the mercury rises and falls with the tilting of the tube.
	10.7.1899 14,235 Hoeft, M.	Electric clock mechanism having a rotary oscillating armature bear-a pawl driving a ratchet wheel, the contacts being made and broken by a radial finger projecting from a jumping disc and a tangential contact plate on the non-reversal pawl of the ratchet wheel. The length of the driving period is governed by a train ending in an escapement.
	18.7.1899 14,806 Magini, G. di P.	Chronograph for registering the duration of a current delivered to an electric lamp or apparatus, the current passing through electromagnets , one of which is used to start the balance of a clock, others operate clutches. When the current ceases the balance is stopped, the duration of the elapsed time being shown on numbered wheels. The clock is spring wound, the key of which cannot be withdrawn, and no current can pass if the key is held to prevent it rotating.
	19.7.1899 14,913 Lake, H.H. Puttkammer, K. Orthmann, F	An electric time programmer to initiate time signals in factories, operating watchmens' clocks, switching electrical circuits. etc. Two twelve toothed ratchet wheels turning once an hour operate contacts, and a large disc driven by the clock is divided into five minute intervals and has a series of holes in concentric rings to hold plugs inserted for the times required, each ring corresponding to a particular circuit.
	22.7.1899 15,135 Hollins, F.T. Leake, F.W.	In secondary clocks the driving armature is connected to a dashpot with the intention of slowing down the return of the armature after attraction. The master clock has a similar arrangement but the armature has an extension which vibrates against a cranked switching arm. Should the current be delayed or fails from some cause, the armature extension falls below the cranked lever and contacts are closed to bring in a reserve master clock. A similar arrangement can be used to bring in the reserve clock should the current persist for too great a time.
	23.8.1899 17,130 Rausch, W.	Time-alarm signalling apparatus for use in hotels and schools, factories, etc. A toothed wheel spaced to give the required duration of intervals is placed on a suitable arbor of the clock and operates a pair of contacts by a lever pressing on the teeth. Switches are provided to put circuits in and out as required independently of the others. Electric bells give the signals.
	29.8.1899 17,504 Goddin, E.A.	Apparatus primarily designed to record the deflections of compass needles and pointers but said to be applicable to control other clocks. Basically light passes through a slot on to one or more selenium cells and the current is fed to two solenoids with a common floating iron core having balance springs, the core carries a registering point resting on a moving drum, recording the motion of the instrument with the light aperture as it alters the balance of the electrical bridge. Many arrangements are suggested.
	7.9.1899 18.132 Getty, F.I.	A movement controlled by a pendulum is driven by a pair of ratchet wheels bearing weighted ratchet levers which are alternately raised by an electromagnet with a lever armature, this action also moves two discs acting as cams which alternately mask the ratchet wheels and allow a circuit closing arm to fall. The gravity arms are thrown up against a pivoted padded stop to prevent over-travel.

ELECTRICAL HOROLOGY PATENTS

1899	25.9.1899 19,261 British Thomson-Houston Co. & Holden, F.	Winding mechanism for a clock mainspring using a pawl and ratchet wheel to convey the motion from a rotary acting armature to the mainspring arbor. As the mainspring unwinds, contact is made between a wing piece on the armature and a circular shaped magnetic strip overlapping it. Once the electromagnet is energised, the contact is improved by the attraction of the magnetic strip and is maintained until the line of centres of the poles is reached by the armature, when it is broken decisively. A condenser and resistance are placed in parallel with the coil to prevent sparking. For use with alternating currents, a lighter armature magnetic strip is employed and another wing on the armature touches a fixed stiff terminal momentarily.
*	26.9.1899 19,384 Lorrain, J.G. (Macdonald,J.G.)	Master clock emitting electromagnetic waves to close the circuit of synchronizing electromagnets and winding motors of secondary clocks. A dashpot on the synchronizing electromagnet armature prevents transient currents operating the device, and it is stated that the operation by waves from other sources is impossible by the employment of a mechanical circuit closer in the secondary clock.
	10.10.1899 20,262 Chambers, R.E.	Illuminated clock dials, the dial is graduated in minutes by a circle of sixty electric lamps, and the hours by twelve clusters of lamps. The time can be indicated by the illumination, one at a time, of sixty other lamps and twelve other clusters; if desired the half-hours may also be indicated. (The answer to a lamp-maker's prayers).
	25.10.1899 21,354 Aron, H. & Aron Electricity Meter Limited.	Relates to improvements in the mechanism for winding-up, or giving tension to a driving-spring, described in Specification No. 24,876 of 1894. Improvements to the contact arrangements and adjustments to the tension of the spring and control of the return stroke are quoted.
	16.11.1899 22,903 Cerebotani, L. Moradelli, C.	Describes means for prevention of over-driving in pawl and ratchet feed mechanisms. A second lever on the pawl drive locks the wheel and has adjustable stops to enable the amount of stroke to be made exact. A spring holds the stroke lever against one stop, and the lever is adapted to enter within pins mounted on the face of the ratchet wheel.
*	12.12.1899 24,673 Butcher, J.	The train from a ratchet wheel to an escapement and balance is driven by the fall of a loose weighted arm having an extension bearing the drive pawl. A pin on the same arm eventually presses a pair of contacts together on an arm bearing a soft-iron armature, attracting the armature to an electromagnet and thus throwing up the driving weight and separating the contacts.
	23.12.1899 25,464 Wescher,M. & Wollenhaupt, P.	Relating to electric time-alarms for use in hotels, etc. A switchboard is set out with a series of pins which are marked to correspond with the different hours and quarters, being separately connected to a ratchet bar. The ends of the wires are projected through the bar and are contacted successively by a metal spring contact, the bar being moved laterally by a weight controlled by an escapement, this being actuated every quarter hour by an electromagnet, the current for which is switched by a four-toothed wheel mounted on the minute-wheel arbor of the clock, also connecting a battery to the electric bell circuits in the various rooms, the other side of the bells being connected by separate leads to movable rings and these are placed on the pin corresponding to the time at which the person is to be called. A switch is fitted in the room to silence the bell, but if opened, movement of the room door closes it again.

ELECTRICAL HOROLOGY PATENTS

1900

2.1.1900 138 Loubery, C.R.	Arrangements for controlling a system of electricity supply to secondary clocks. Each clock is tuned to respond to a particular frequency placing condensers across the coils of electromagnets. Other arrangements are detailed, each circuit of clocks has a particular frequency of operation and is not affected by any other.
12.1.1900 722 Miles, J. & Miles, R.H.	Alarm for use in billiard rooms, bakeries, etc. A spring movement having only a minute hand is wound up for the required number of minutes by turning the hand to the required time, at the end of its travel, an arm turning with the hand completes an electric circuit and rings an electric bell.
23.1.1900 1416 Brook, F. & Gaunt, J.S.	Tell tale clock, the only electrical part being that the printing on a workman's check may be performed electrically, most of the specification deals with the mechanical details of the check system, and the method of checking in and out.
30.1.1900 1904 Wolf, S.	An alarm for waking a person in bed and which continues to ring until the person gets up, a switch fixed below the bed has its contacts closed by the weight of the person, and open when the weight is removed.
30.1.1900 1906 Haenichen, F. & Haenichen, O.A.	A complicated mechanism for maintaining a pendulum. A crutch oscillates with a seconds pendulum bearing two pawls which alternately drive a ratchet wheel of thirty teeth carrying the seconds hand, a small snail cam on this arbor operates a lever to drive a ratchet wheel carrying the minute hand, whilst the hour hand is driven similarly. The energy of the pendulum is maintained by a gravity arm, and another ratchet wheel independent of the time ratchet, is driven by another pawl on the pendulum crutch, one tooth being longer than the others so it comes to rest near contact pins and strips, upon which the crutch sends a succession of exciting and depolarizing currents to increase the amplitude of the pendulum swing until the driving pawl takes up the long tooth. To prevent the depolarizing current becoming an exciting current, it is disconnected each time the armature is attracted to the electromagnet driving the clock.
22.2.1900 3527 Hansen, H.	Conversion of any clock to sound an electric alarm, an insulating-piece bearing a terminal and a pallet is mounted on the bezel by a spring clip, the hour hand touches the pallet at the appointed time, completing the circuit to ring an electric bell.
22.2.1900 3535 Hookham, G.	Electric clocks driven by continuous current electric motors of any form or by alternating current induction motors such as those described in Specification No. 17,159 of 1899. The escapement wheels are connected to their shafts by springs in order that the motors can start freely and accumulate sufficient energy to start the pendulums. A hysteresis motor may be used, and maintaining power is fitted in the form of a spring to drive the clock should the motor stop for a short while.
3.3.1900 4109 Golby, F.W. (Hansen, H.)	The minute hand of a master clock closes the circuit of electromagnet every minute, the armatures of which drive pairs of wheels of sixty teeth, one of which is masked by the other except for every twelfth tooth, the arbor of one wheel carries the minute hand, the other the hour hand. Also shown is an arrangement for a striking-hammer of the master clock to put into circuit electric bells at the secondary clocks, at each stroke a pair of contacts are closed.
29.3.1900 4921 Grant, J.	Escapements of distant clocks are operated by periodic currents from master clocks. Spring contacts on the master clock are operated by a cam every revolution, on the same arbor is a long fly released by a wheel on the master clock. The drive to the cam and fly is not described but appears to be a separate spring-driven train.

ELECTRICAL HOROLOGY PATENTS

* 1900	22.3.1900 5445 Arlincourt, A.L.A.C. d'.	Striking mechanism of some ingenuity consisting essentially of a wheel with groups of contacts mounted on its periphery to correspond to the natural numbers up to twelve and nearly touch a fixed electrical contact. An electromagnet receiving a current at the hour from a master clock attracts a divided lever armature (described in Specification No. 8156 of 1899) and the latter operates a lever extending to a ratchet wheel in gear with the striking wheel. The contacts occupy arcs of three lengths and the teeth on the ratchet wheel are graded accordingly, the variable feed of the ratchet wheel lever being made to correspond by means of a snail turning with the striking wheel and altering the amount of travel of the lever by the movement of a limiting stop. After taking up a tooth on the ratchet wheel, the current ceases and the striking wheel is turned by a weight attached to the ratchet lever, the rate being governed by an escapement connected by a gear train.
	14.4.1900 7031 Lake, H.H. (Dudley, W.J.)	Electric clocks in which the pendulum drives the hands and a gravity arm subjected to an electromagnet keeps the pendulum going. Another gravity arm lifted by the pendulum turns a ratchet wheel to drive the hands, the pendulum driving gravity arm is reset by a pivoted armature of an electromagnet situated between the plates. The lifting of the driving gravity arm for the clock train completes an electric circuit and the electromagnet lifts up the gravity arm impulsing the pendulum and resets it for the next impulse operation.
	25.4.1900 7675 Lake, H.H. (Cuenod, H.)	Basically a constant speed motor to drive hands with greater power, or to drive astronomical instruments, etc. The electric motor makes use of continuous currents to drive the armature the speed being governed by a governor similar to that shown in Specification No. 2305 of 1862, the governor weights being large enough to act as a flywheel and smooth out minor variations of speed. Another winding on the armature carrying continuous current excites polyphase currents in an armature (static) and these are fed by thre or more connections to the secondary clock. This motor consists of a permanent magnet, three or more inducing coils with iron cores and pole pieces and enclosed in an iron ring. If a three-phase motor with six poles is used, the cores are made into one with a ring round which the coils are wound.
*	15.5.1900 8938 Thrasher, S.P.	Chronoscope or electric clock with electromagnetically maintained pendulum. A pin on the pendulum rod rocks a fork bearing two pawls driving a ratchet wheel on whose arbor the seconds hand is mounted. Projections on the ratchet wheel press an electric key in the circuit of an electromagnet and this drives a fine-toothed ratchet wheel turning the minutes drum. In a similar manner the tens of minutes drum is driven from the unit drum. The energy of the pendulum is restored by a striking tumbler acting on the end of the pendulum rod, lifted after each impulse by a pivoted armature of an electromagnet, the tumbler being held by a latch until the amplitude of the pendulum is reduced, upon which a pivoted notched lever swinging at the bottom of the pendulum fails to slip over a pin on the latch, disengages the latch and the pendulum is impulsed. At the end of the impulse, the tumbler hits an oblique slide, pushing it to one side to close a contact pair and energise the electromagnet and reset the tumbler. (A mechanical Hipp toggle arrangement).
	22.6.1900 11,340 Fischer, M.	A wheel train driven by weights or spring is released once a minute by the escape wheel of a clock, the train then rocks the armature of an electrical generator to generate alternate reversed currents for operating secondary clocks. A steel band is used to support the driving weight. Various arrangements of the generator are described. In one the magnets move and the armature is stationary.

ELECTRICAL HOROLOGY PATENTS

1900	3.7.1900 11,965 Barr, A. Stroud, W. & Becker, L.	Proposals for systems of clock, electric clocks and secondary clocks. The secondary clock is of the usual pattern with a driving and locking pawl to prevent reverse or false motion, in a modification the driving pawl acts by pulling, moving between a stationary stop and the locking pawl. To indicate the working of the secondary clocks, each is fitted with the means to short a common line to earth, either directly or through a resistance at different times: the line wire passing current through a galvanometer from a central battery to indicate that the clock has functioned. If the circuit closes at the wrong time, an alarm signal is sounded. Other arrangements are suggested.
	11.8.1900 14,409 Harris, J.	Electrically wound clock for use with electricity meter. A cylinder is caused to make a rotation in one direction once a minute by a drum connected with it and carrying a pawl engaged by a loose wheel geared to a toothed segment when this is turned by an electromagnet attracting an armature. The drum contains a coiled spring which connects it to a toothed wheel geared to an escapement; after unwinding and reaching its original position, a contact bar on the wheel closes the electrical circuit containing the electromagnet to rewind the spring.
	23.8.1900 15,044 Fattorini, E.	An alarm clock modified to sound an electric bell. Mounted friction-tight on the hour hand arbor and bearing an alarm setting dial, is a wheel meshing with one with twice as many teeth so it will turn once in twenty-four hours. A snail cam on the face of this wheel allows a lever to fall and make contact to close a circuit containing an electric bell.
	1.9.1900 15,591 Boult. A.J. (Katzenstein, F.)	A balance wheel controlled by a spiral spring is oscillated by two electromagnets acting on two longitudinal iron bars mounted on the balance arbor. A pin on the balance oscillates a fork lever to switch the contacts necessary to control the electromagnet circuit if the balance amplitude becomes too great, but normally a pawl on the balance moves a spring contact to impulse the balance at every oscillation, an eccentric on the balance arbor rocks a shaft which turns a ratchet wheel by a pawl once each minute. this wheel drives a cam at one revolution each minute to operate the electricity meter. To ensure the balance starts from rest, the iron bars are not quite opposite the electromagnet poles, so as soon as current flows, the balance begins to turn.
	12.10.1900 18.175 Royer, P.	Advertising clock which can be combined with an electric alarm. An alarm hand turns concentric with the hour and minute hands and can be set by hand is contacted by a roller on the hour hand to complete the circuit of an electric bell. It is stated that a combination of a clock train driving a watch train will give a month's duration of running without rewinding.
	17.10.1900 18,534 Andersson, H.E.	Electrical rewinding of clocks of the type described in Specification No. 26,769 of 1898, using an oscillating armature controlled by a mercury interrupter to make and break the circuit of the electromagnet. The feed action of the driving pawl is limited by a fixed pin and this allows the armature to fall as a hammer on the contact-maker.
	31.10.1900 19,486 Leake, F.W.	An arrangement to ensure that a secondary clock operated by periodically transmitted currents can only step one tooth of the ratchet wheel for each impulse received. The device is a spring-biassed anchor rocked by a spring and this allows only one tooth to pass at each operation. The ordinary pawl for driving and a back stop are fitted also.

ELECTRICAL HOROLOGY PATENTS

1900	24.12.1900 23,589 Lebret, A.E.	Balance wheel controlled clock with electromagnetically rewound mainspring, a cam on the second wheel arbor operating spring contacts to close the circuit of the electromagnet, upon which the armature is attracted and turns a ratchet wheel by means of a pawl. In a modification a quick cam and a slow spring terminal to touch a fixed terminal every four minutes.

ADDENDA INCLUDED IN 1900 ABRIDGEMENTS

1880	3.7.1880 2730 Wetter, J. (Shuey, W.H.)	A complicated apparatus for notifying automatically the hour fixed for the departure of trains, an intermittent bell signal is sounded before the time of departure and a second bell at the actual time of starting of the train. Essentially the mechanism is a programmable timer which can be adjusted to the twenty-four hour timetable of a busy main-line station, most of the details are of the mechanical construction.
1881	11,5.1881 2053 Noad, J.H.	- Brass clock wheels, bearings and other parts, are coated with iron or steel by electrolysis. (The reason for doing so is not stated). Provisional protection only granted.
1882	23.2.1882 Des Vœux, F. (Cumming, G. & Brinkerhoff, C.M.)	The contacts on an electric clock or similar apparatus consist of brass or platinum discs, on the edge of each of which a hard platinum or other wire is secured. The wire may be triangular or circular in section, or a thin plate may be mounted between two discs. The contacts are mounted on set-screws so that they turn freely, their operating planes being preferably at right-angles to each other.
1883	12.9.1883 4365 Jolin, P. Parsons, J. Purcell, M.F.	The core of an electromagnet is provided with a commutator fixed on one of the arbors of the clock, as the current is interrupted, the core rises and falls and actuates a pawl engaging a ratchet mechanism mounted on the arbor of the mainspring. (Provisional protection only granted).

This list was compiled between 20th July and 31st July 1984 from the Patent Abridgements for Horology 1855-1900, some additional information being taken from Complete List of English Horological Patents up to 1853 by Charles K. Aked, published in 1975.

ELECTRICAL HOROLOGY PATENTS

Number of Patents issued in the Years 1840-1930

1840	0
1841	2
1842	0
1843	1
1844	0
1845	1
1846	0
1847	2
1848	0
1849	2
1850	0
1851	0
1852	1
1853	0
1854	0
1855	1
1856	4
1857	1
1858	1
1859	0
1860	3
1861	1
1862	3
1863	1
1864	3
1865	3
1866	4
1867	3
1868	3
1869	4
1870	3
1871	1
1872	3
1873	4
1874	5
1875	3
1876	6
1877	5
1878	10
1879	2
[2] 1880	9
[2] 1881	12
[2] 1882	15
[2] 1883	13
1884	12
1885	12
1886	20
1887	19
1888	14
1889	12
1890	14
1891	22
1892	17
1893	14
1894	17
1895	9
1896	12
1897	12
1898	11
1899	21
1900	17
1901	15
1902	15
1903	8
1904	16
1905	27
1906	16
1907	15
1908	25
1909	23
1910	20
1911	20
1912	24
1913	22
1914	11
1915	9
1916	6
1917	4
1918	15
1919	13
1920	17
1921	15
1922	21
1923	26
1924	25
1925	16
1926	23
1927	34
1928	23
1929	14 *

* Plus extra ones in 1930 entries.

[2] See page 47 for addenda.

ELECTRICAL HOROLOGY PATENTS

N A M E   I N D E X

For the period 1840-1900

The numbers following the names refer to the page numbers in the main list of entries relating to electrical horology patents. Some names have more than one entry per page, in which case the page number is followed by the number of entries in parentheses. No chronological list is given since the main list itself provides this information. Note that there may be small discrepancies in initials and spellings so that an applicant may be listed twice in order that no name is omitted. All the names are listed which appear on the specification, but it must be borne in mind that often the patent was applied for by a Patent Agent on behalf of the inventor, in which case the true applicants are those whose names are in brackets following the first name. Some of the Patent Agents are shown in the name list by an asterisk.

ELECTRICAL HOROLOGY PATENTS

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